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Kamei et al.

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(54) **CONNECTOR DEVICE**

(71) Applicants: **JAPAN AVIATION ELECTRONICS INDUSTRY, LIMITED**, Shibuya-ku, Tokyo (JP); **HONDA MOTOR CO., LTD.**, Minato-ku, Tokyo (JP)

(72) Inventors: **Yuji Kamei**, Tokyo (JP); **Akira Kuwahara**, Tokyo (JP); **Makoto Kawahara**, Tokyo (JP); **Ryo Fujii**, Tokyo (JP)

(73) Assignees: **JAPAN AVIATION ELECTRONICS INDUSTRY, LIMITED**, Tokyo (JP); **HONDA MOTOR CO., LTD.**, Tokyo (JP)

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(51) **Int. Cl.**

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H01R 13/629	(2006.01)
H01R 13/502	(2006.01)

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(52) **U.S. Cl.**

CPC ***H01R 13/62977*** (2013.01); ***H01R 13/502*** (2013.01); ***H01R 13/62938*** (2013.01); *H01R 13/62955* (2013.01); *H01R 13/635* (2013.01);

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(58) **Field of Classification Search**

CPC H01R 13/62938; H01R 13/658; H01R 13/26; H01R 13/62955; H01R 13/62933; H01R 13/62905; H01R 23/7005

USPC 439/660, 157

See application file for complete search history.

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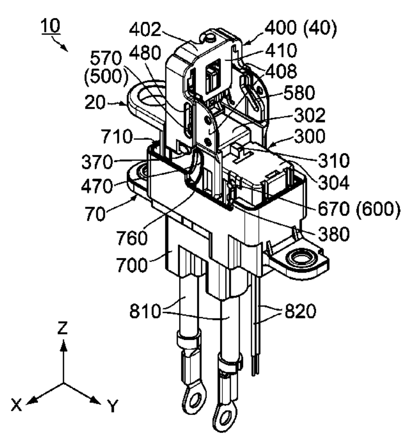
Primary Examiner — Abdullah Riyami
Assistant Examiner — Vladimir Imas
(74) *Attorney, Agent, or Firm* — Holtz, Holtz & Volek PC

(57) **ABSTRACT**

A connector device comprises a connector and a mating connector connectable with each other. The mating connector comprises a mating primary terminal and a mating secondary terminal. The connector comprises a primary terminal, a secondary terminal, an operation member and a push-back mechanism. The operation member changes its state from an initial state to a second state via a second state. When the state of the operation member is changed to the first state, the primary terminal is connected to the mating primary terminal. When the state of the operation member is changed to the second state, the secondary terminal is connected to the mating secondary terminal. When the state of the operation member is changed to the first state, the push-back mechanism applies a push-back force to the operation member to change the state of the operation member back toward the initial state.

10 Claims, 15 Drawing Sheets



(51) **Int. Cl.**
H01R 13/635 (2006.01)
H01R 31/08 (2006.01)

(52) **U.S. Cl.**
CPC *H01R 24/005* (2013.01); *H01R 31/08* (2013.01); *H01R 2201/26* (2013.01)

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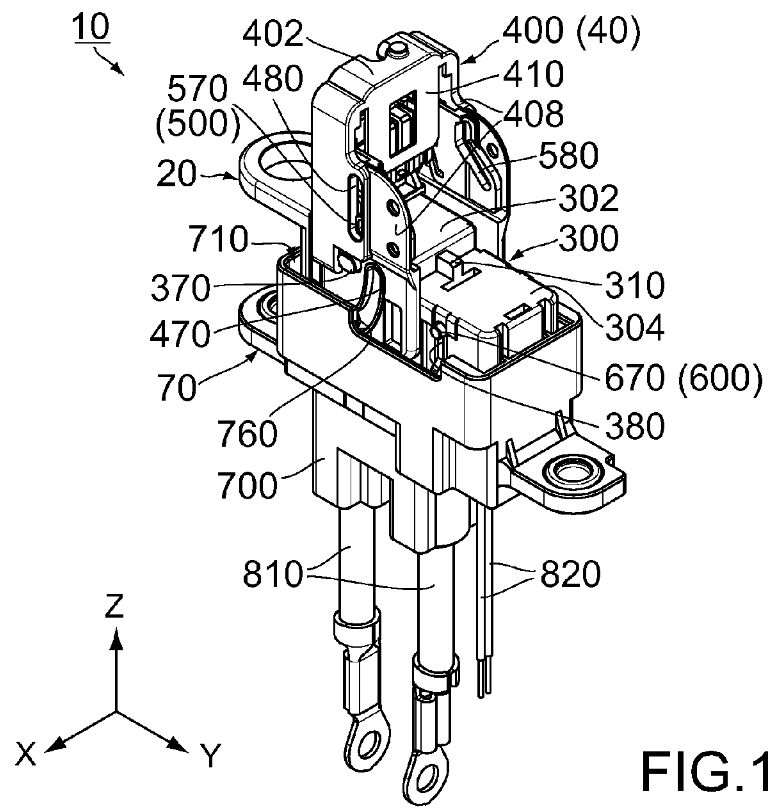
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670 (600)
760
380
700
810
820
Z
X
Y

FIG.1

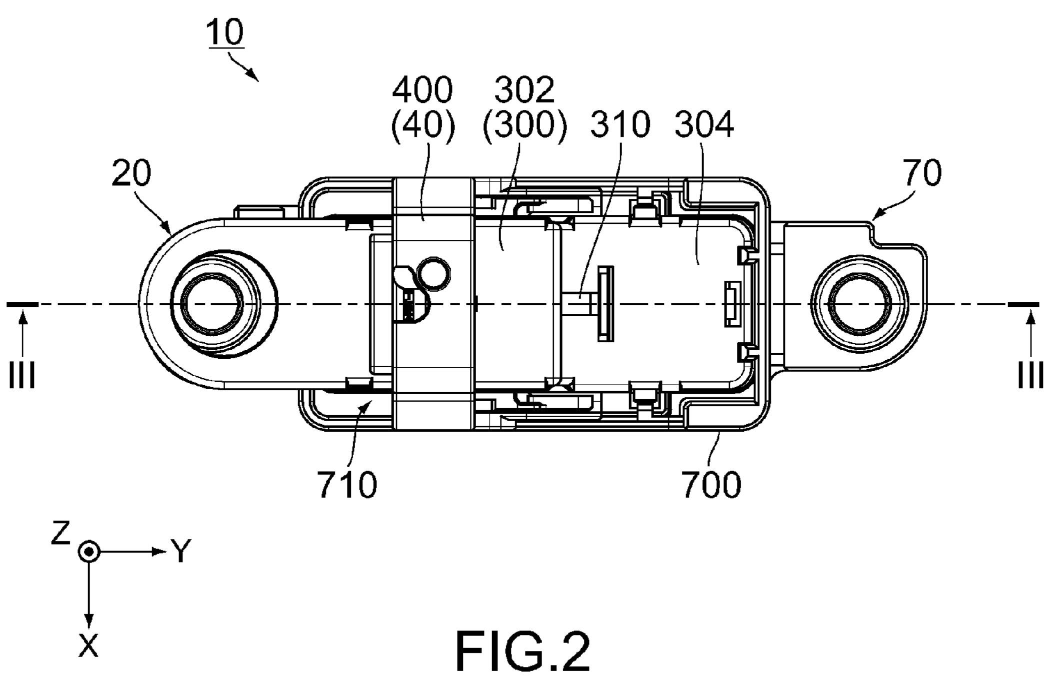
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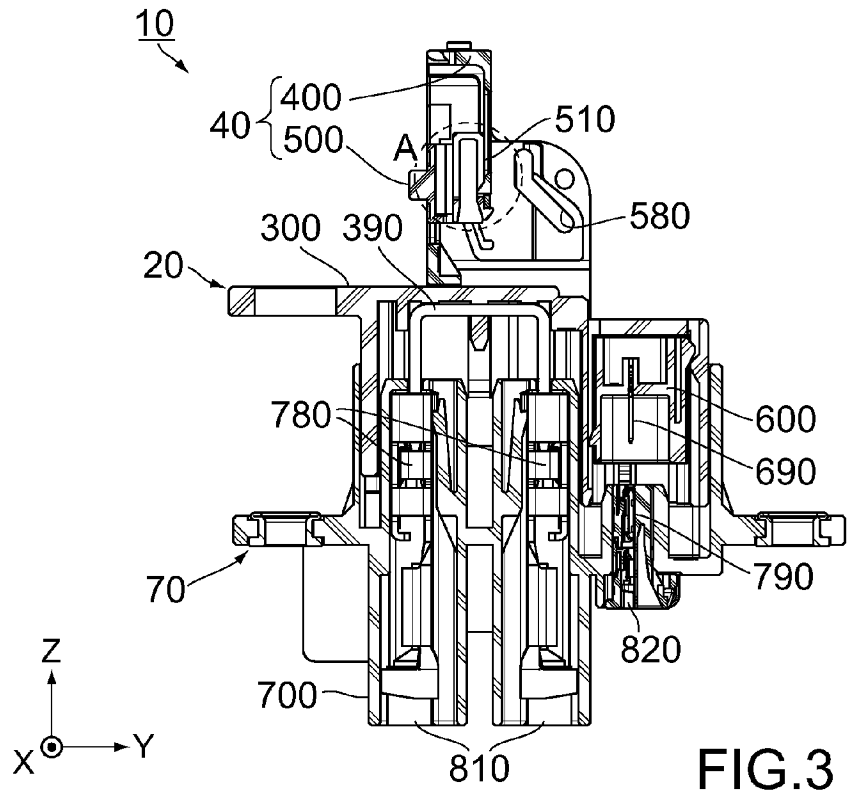
FIG.2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790
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820
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X
Y
810

FIG.3

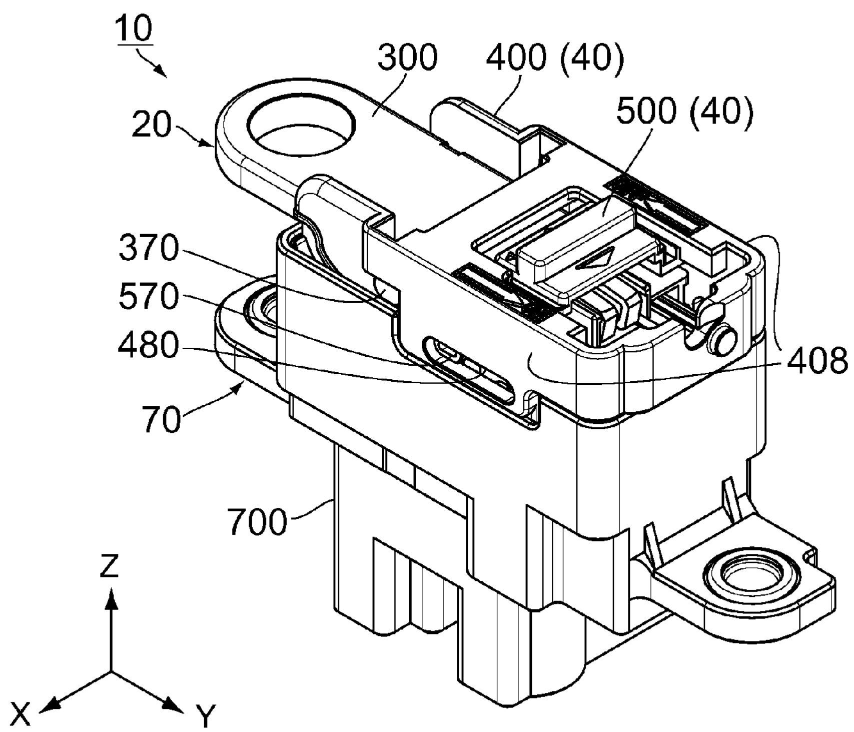
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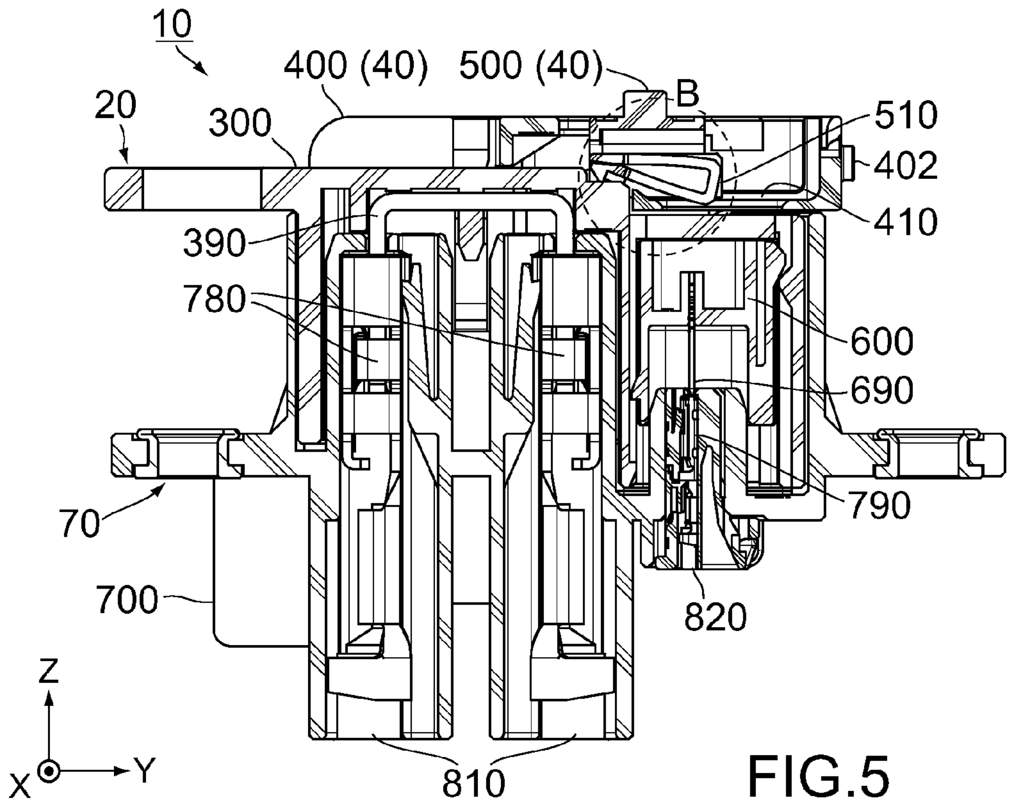
FIG.4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402
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780
600
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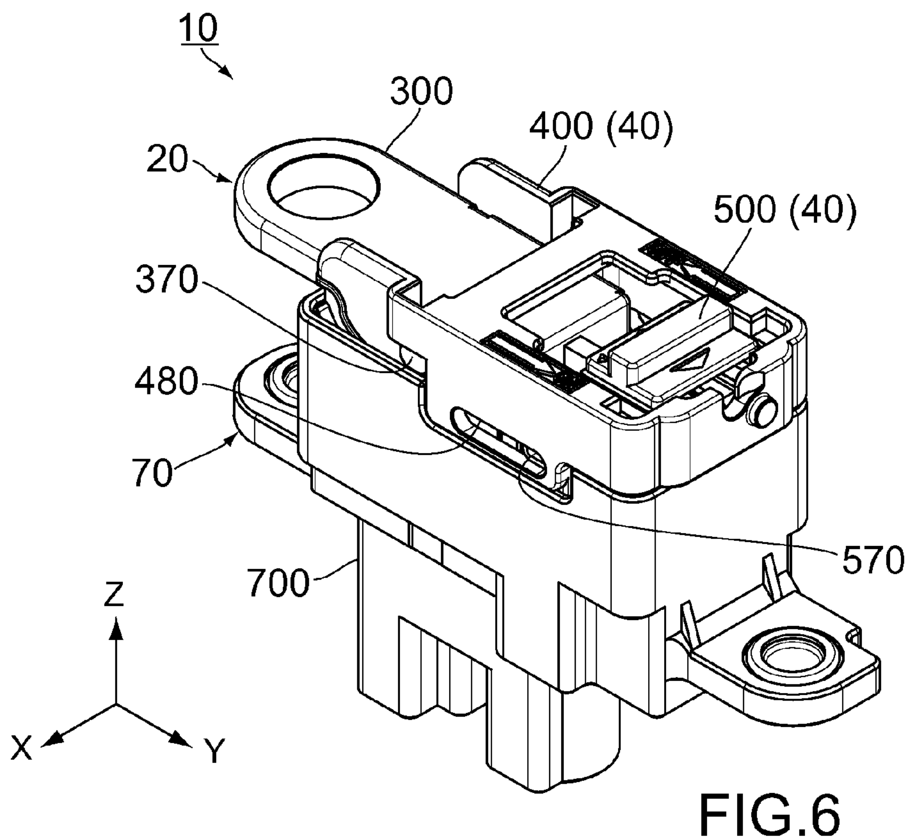
70
790
700
820
Z
X
Y
810

FIG.5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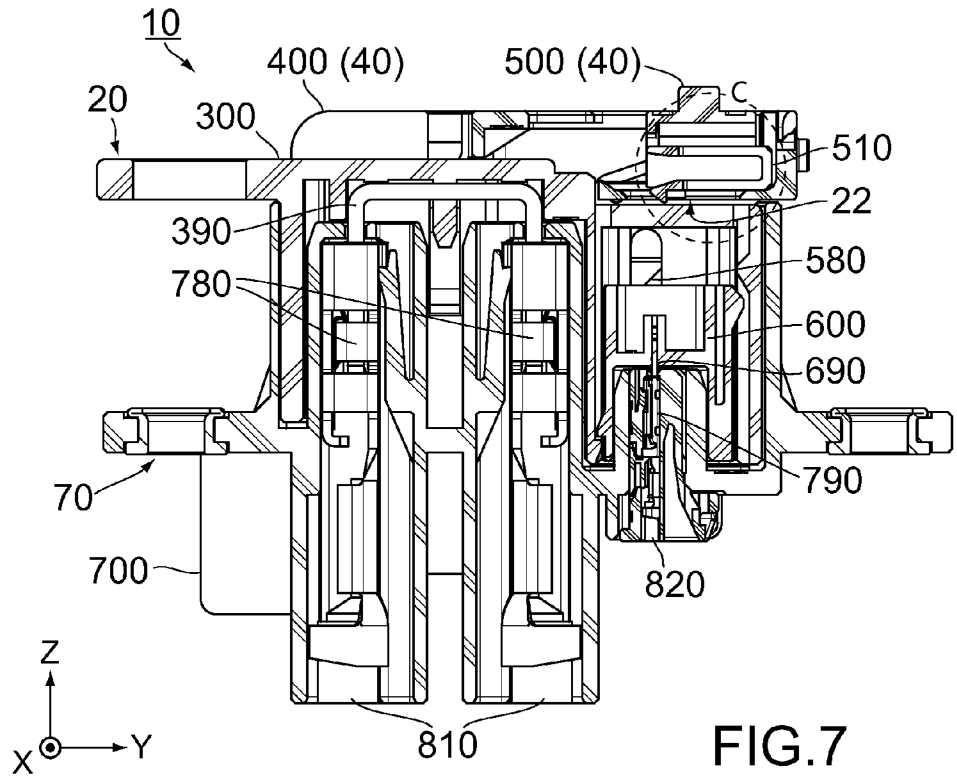
570
700
Z
X
Y

FIG.6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510
22
390
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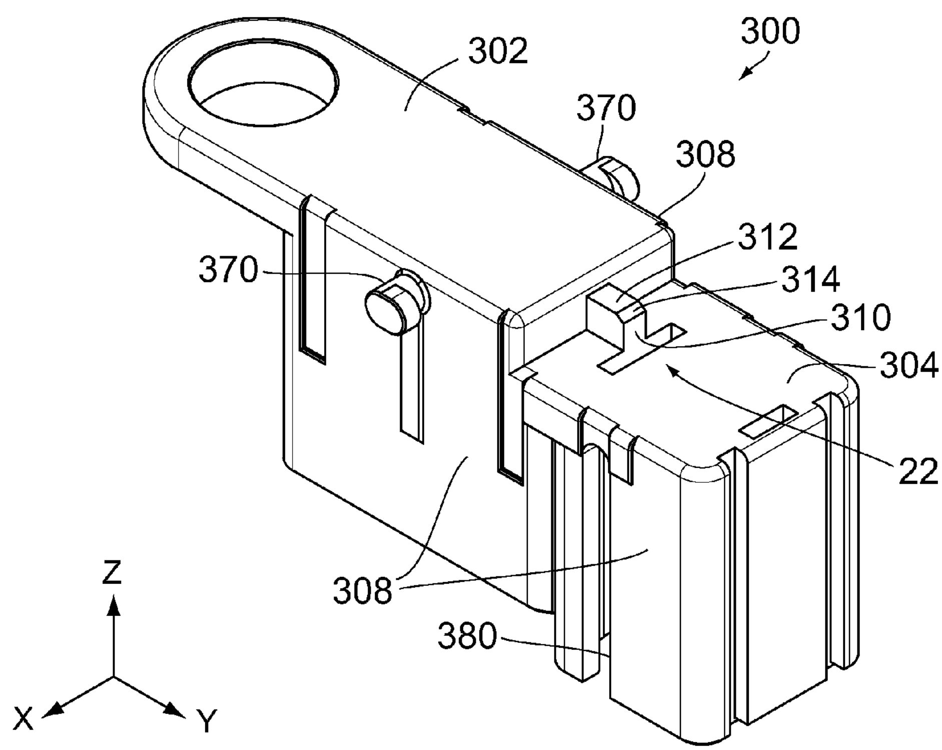
780
600
690
70
790
700
820
Z
X
Y
810

FIG.7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22
308
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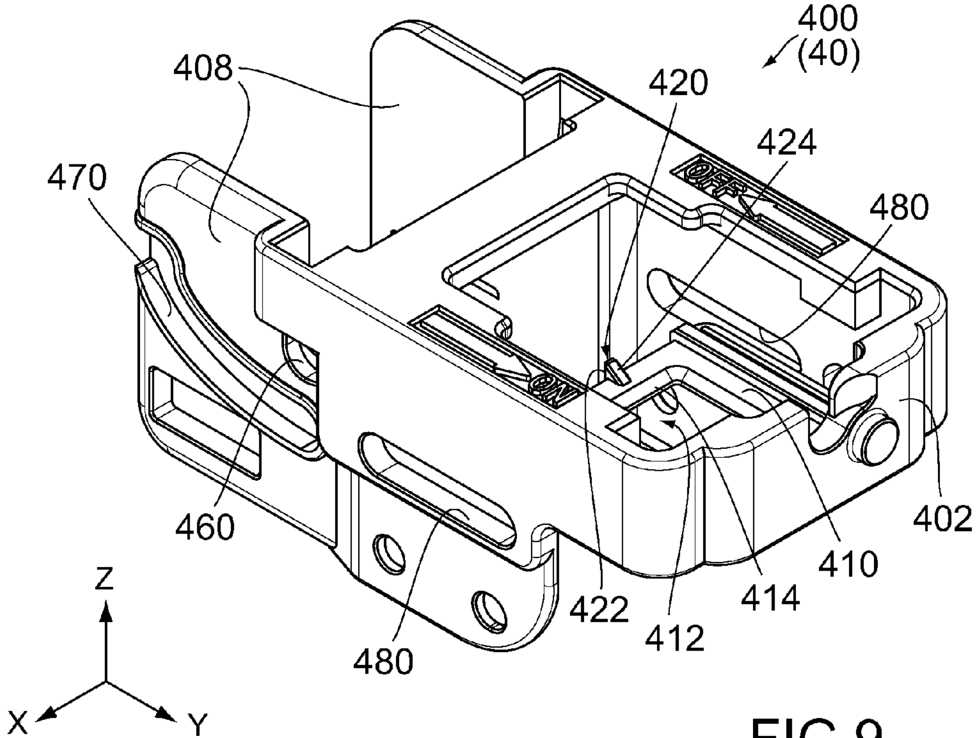
380
X
Y

FIG.8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480
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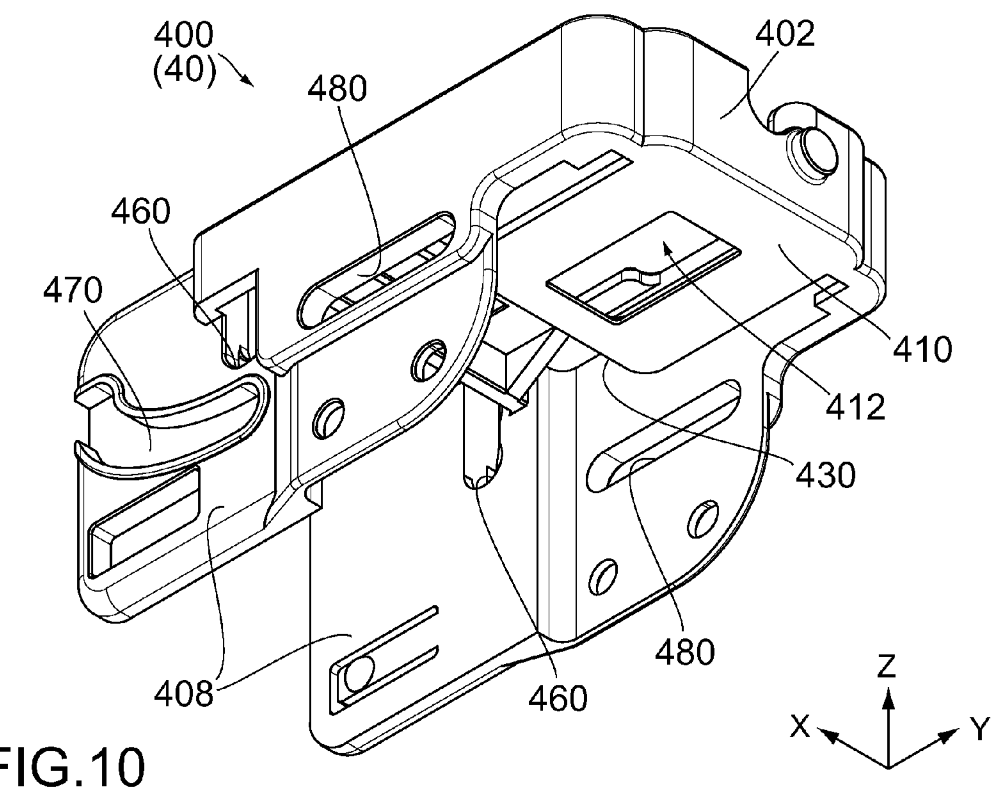
Y

FIG.9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480
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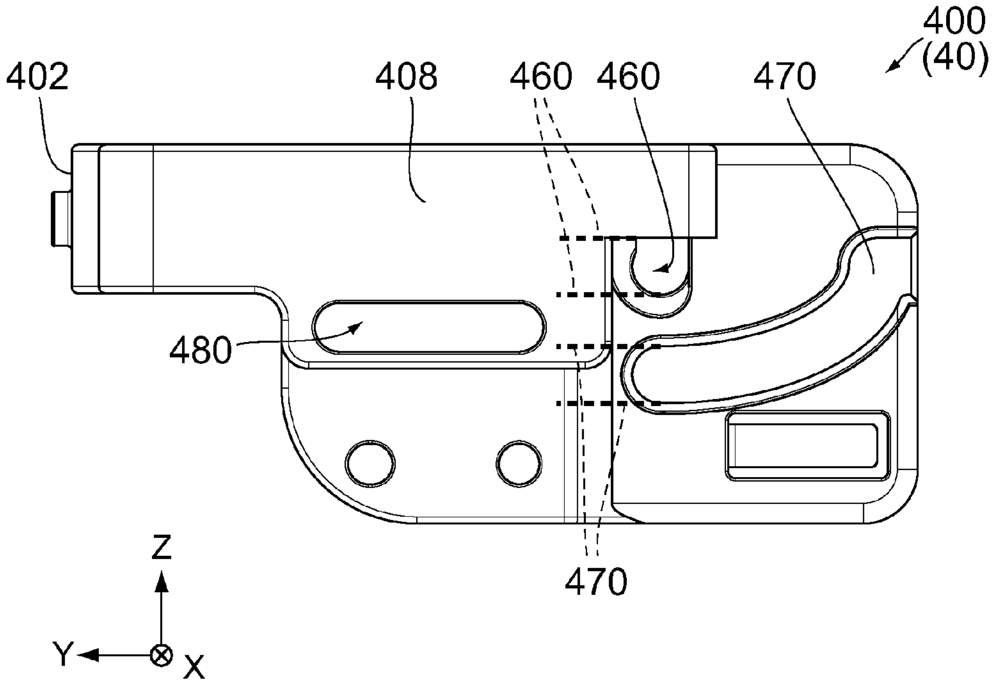
FIG.10



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470
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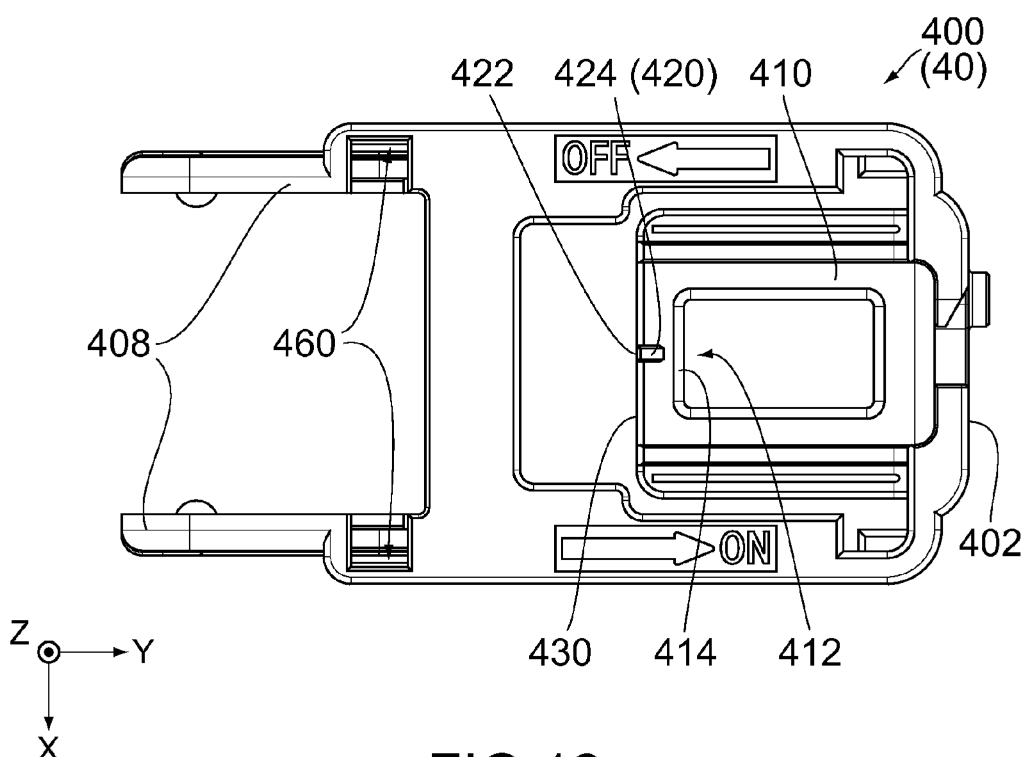
Y
X

FIG.11



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424 (420)
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460
ON
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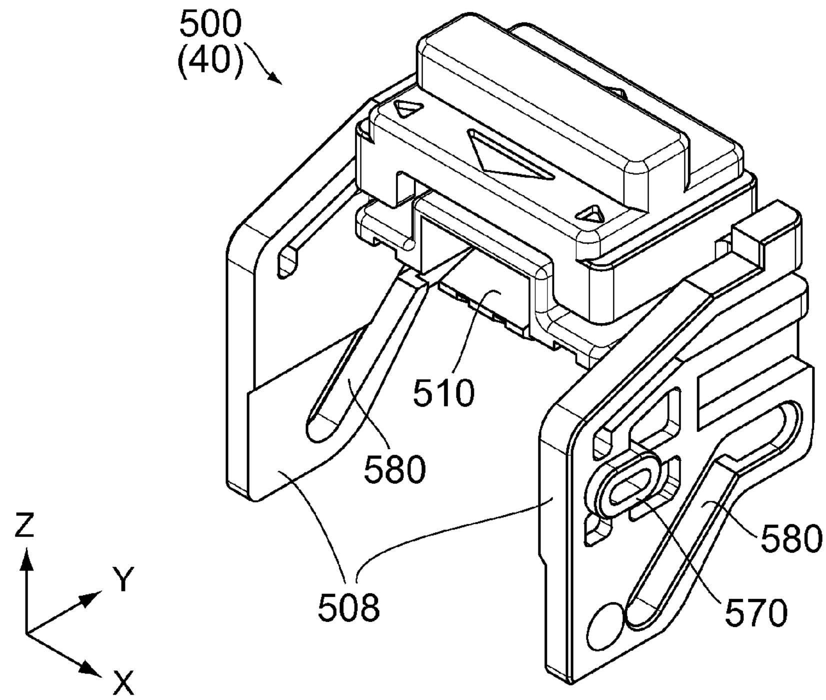
430
414
412
Z
Y
X

FIG.12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508
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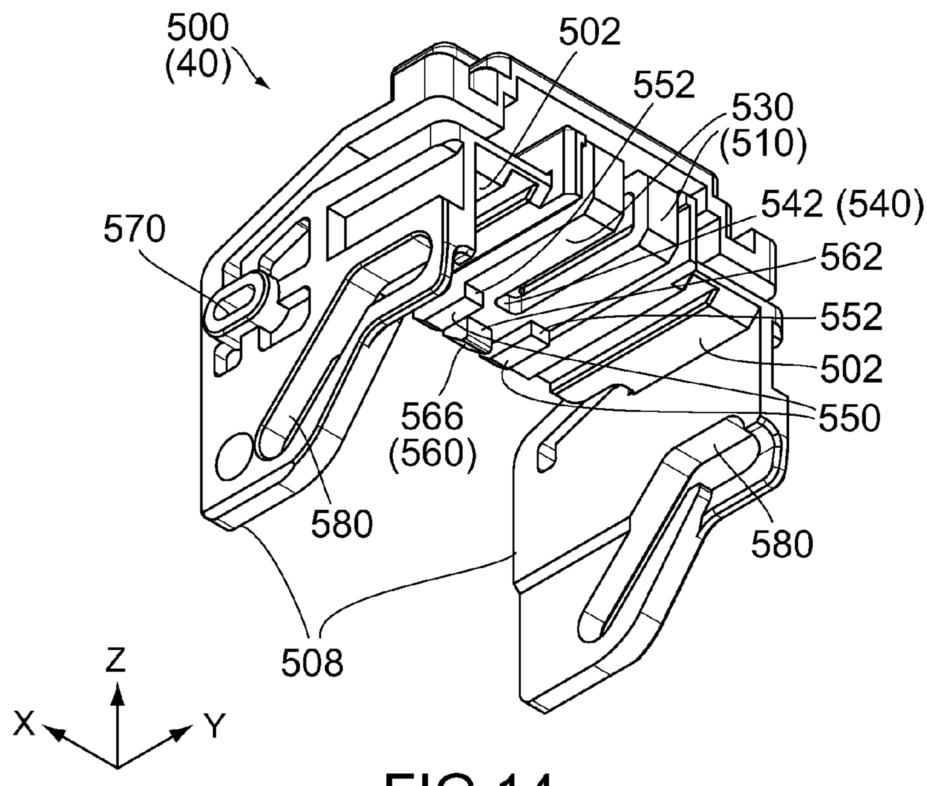
Y
X

FIG.13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552
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562
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550
580
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508
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X
Y

FIG.14

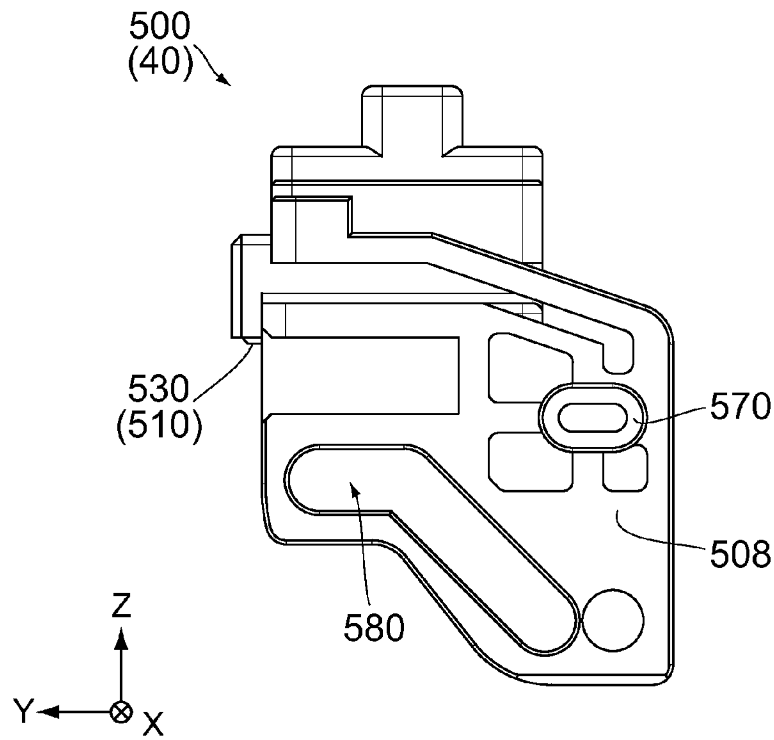
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FIG.15

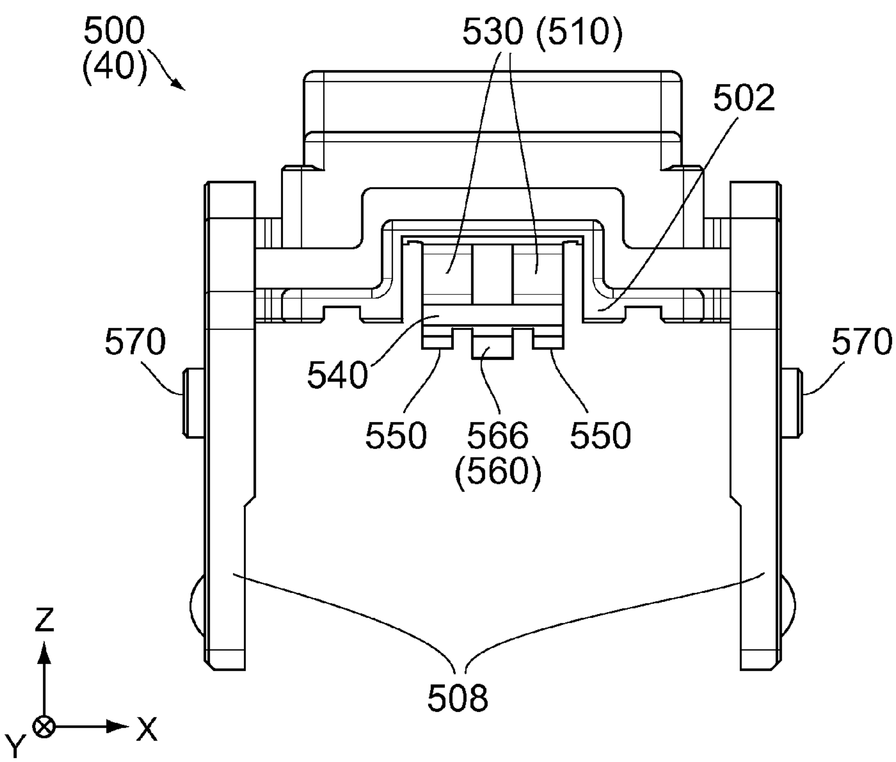
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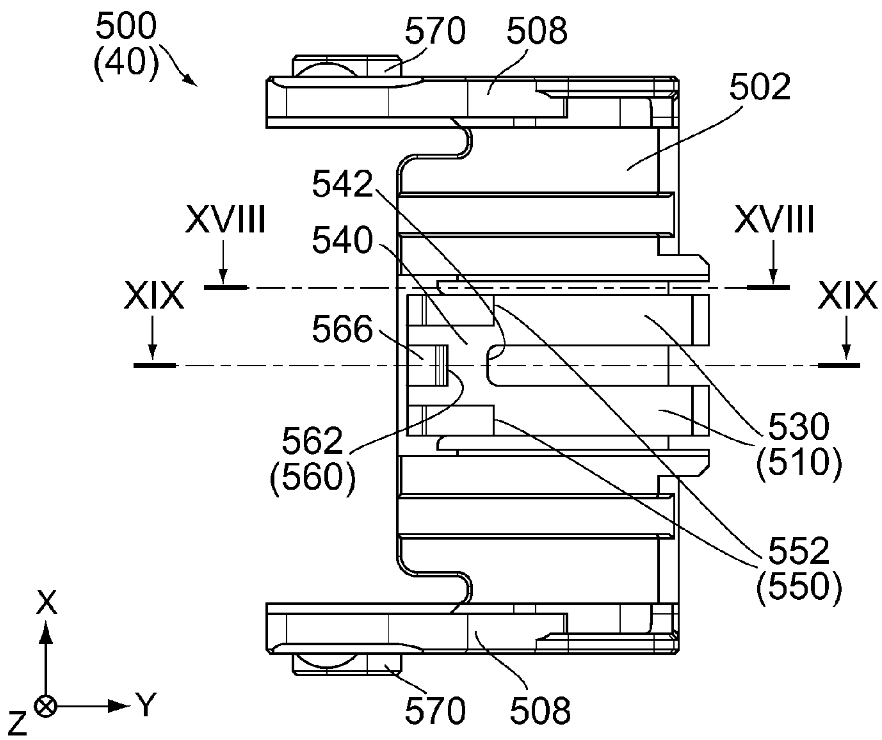
FIG.16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508
502
542
XVIII
XVIII
540
XIX
XIX
566
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(510)
562
(560)
552
(550)
X
Z
Y
570
508

FIG.17

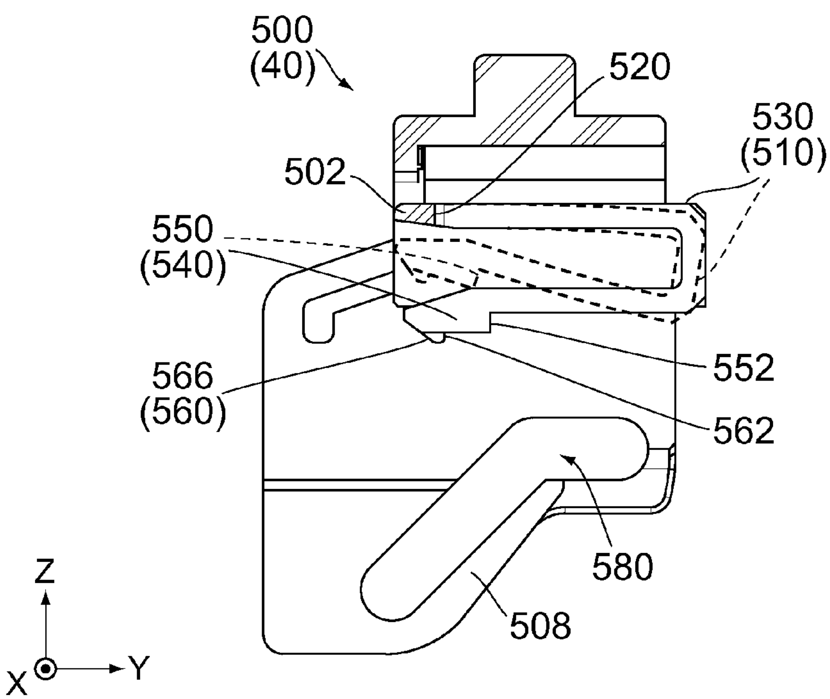
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FIG.18

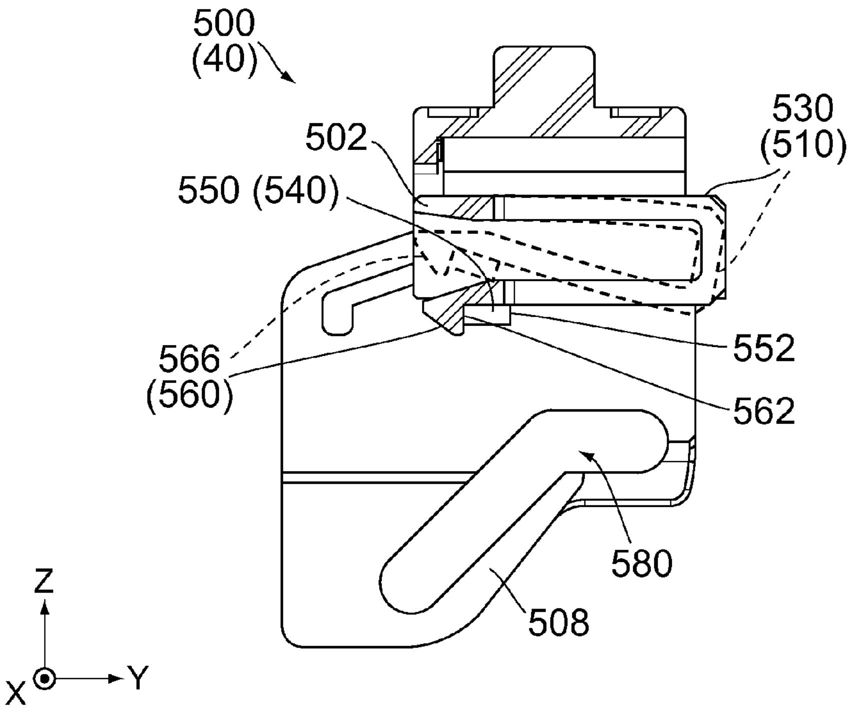
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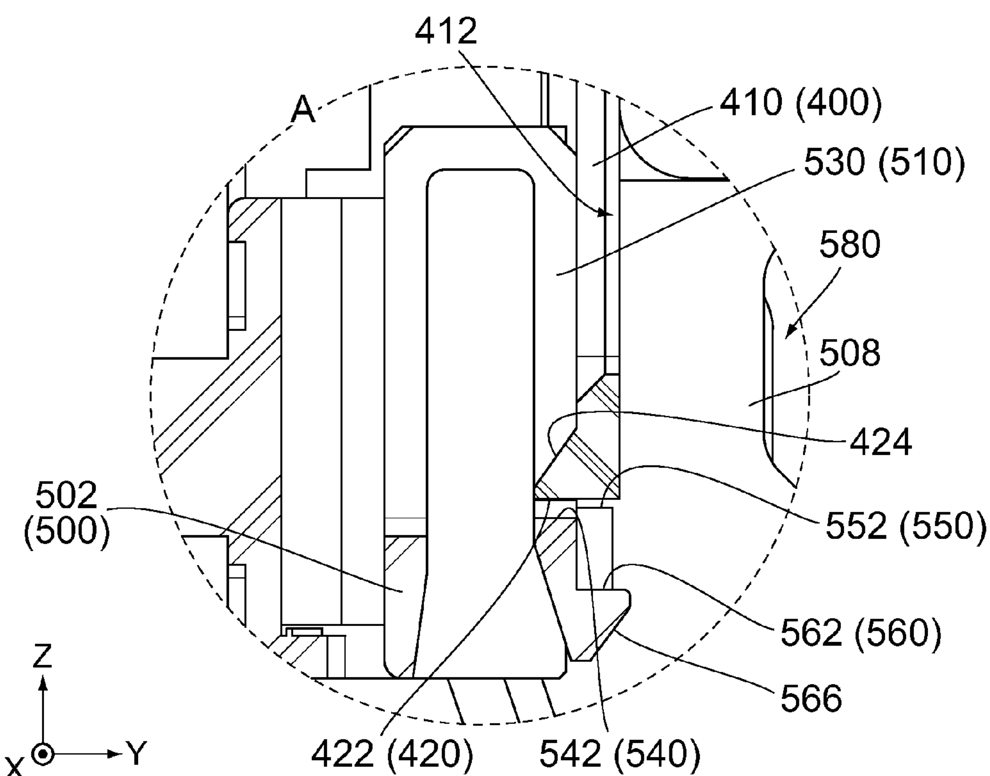
FIG.19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410 (400)
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566
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X
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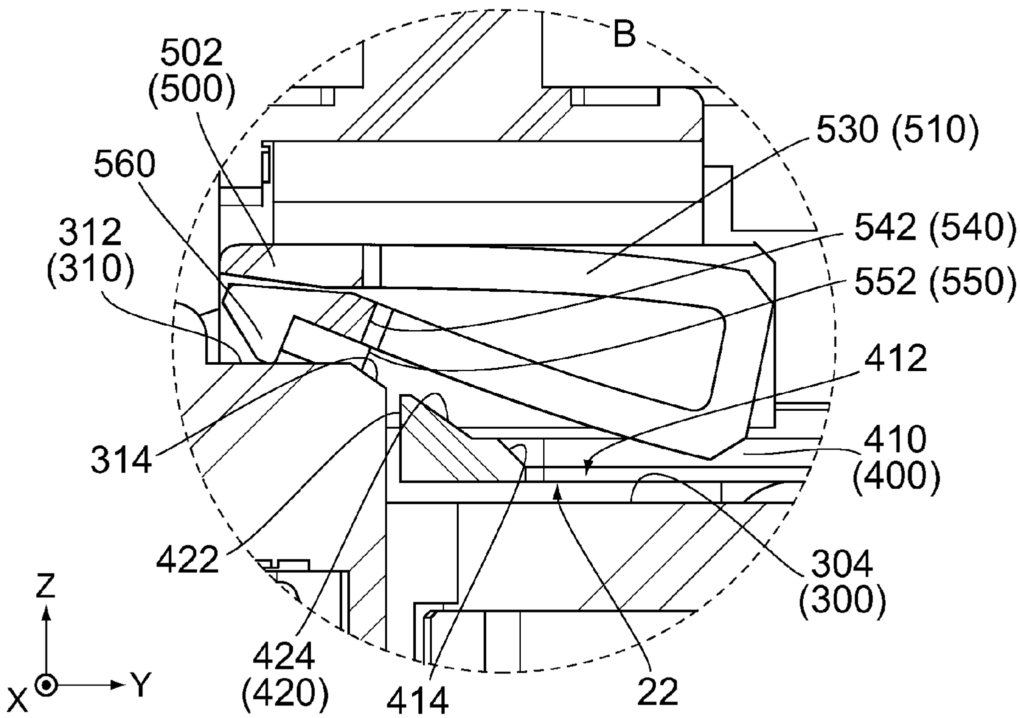
422 (420)
542 (540)

FIG.20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(400)
304
(300)
Z
X
Y

FIG.21

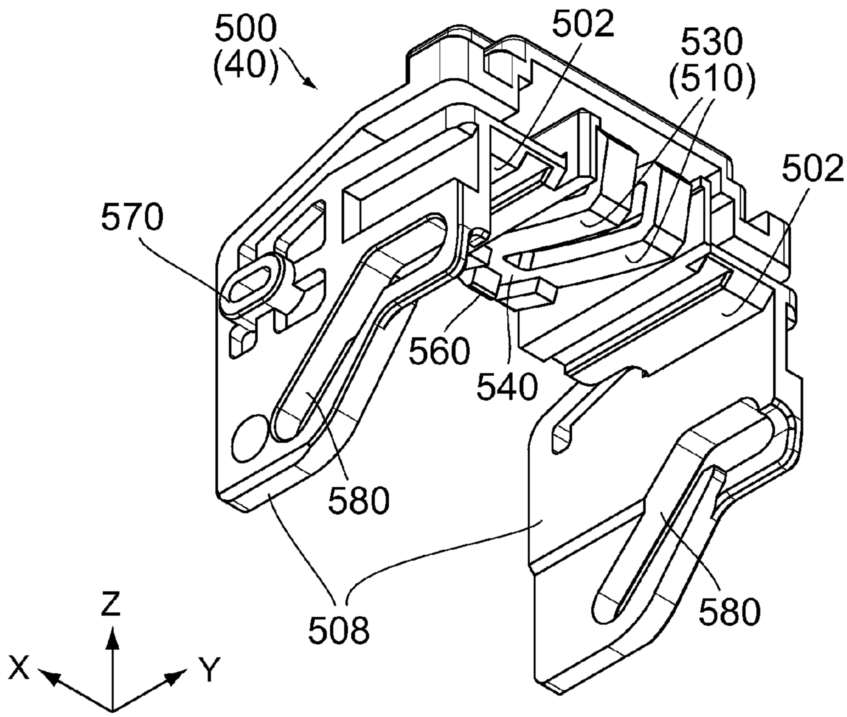
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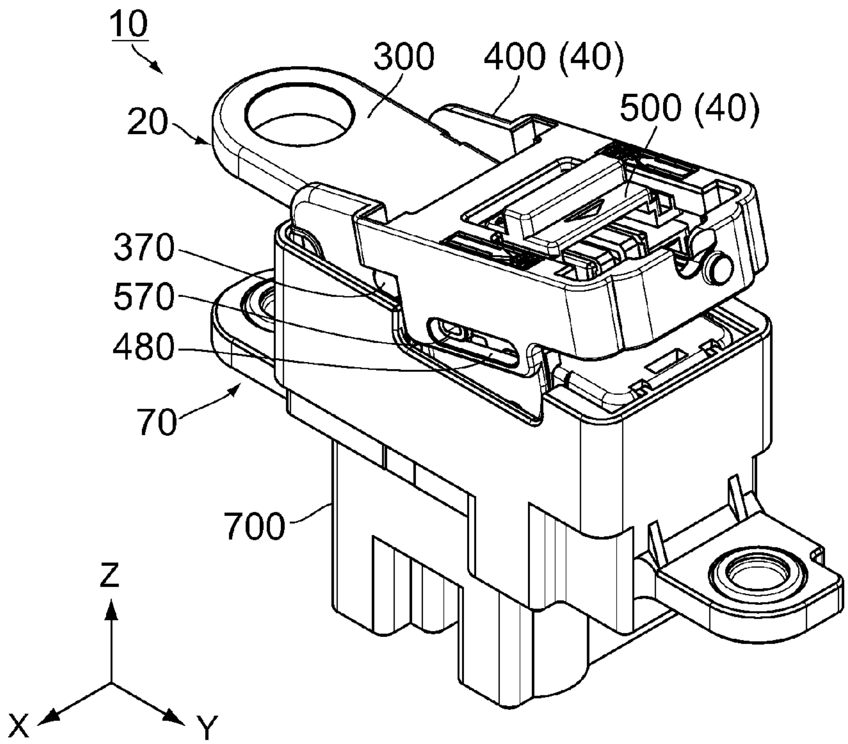
FIG.22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Z
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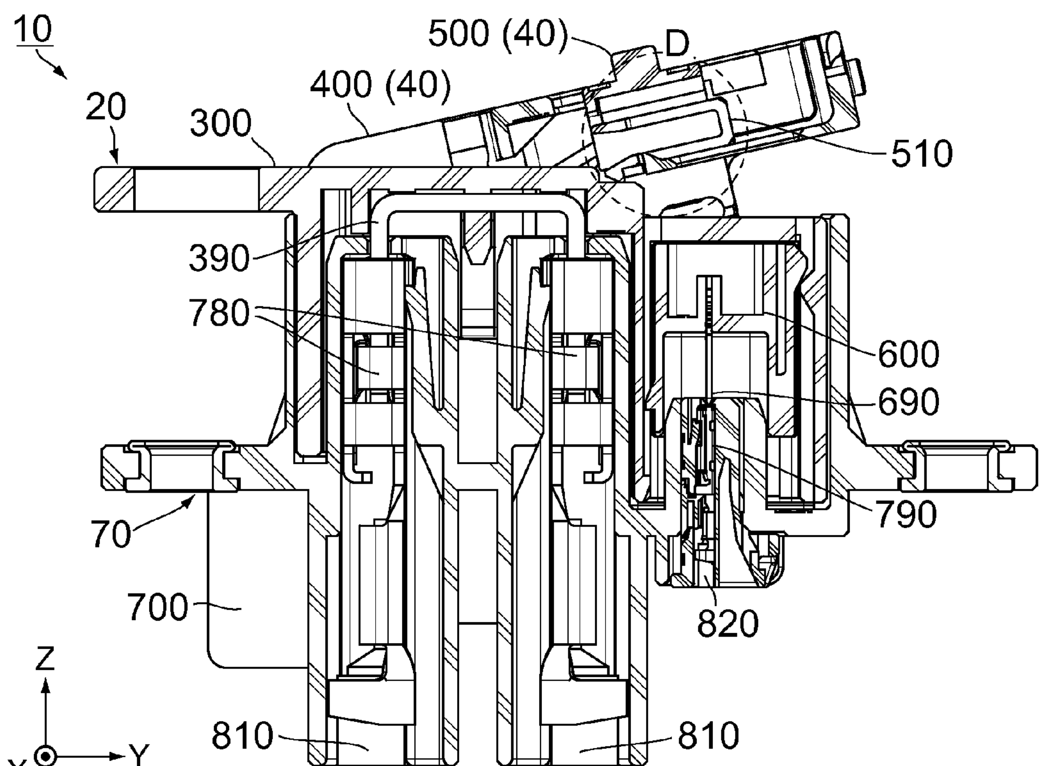
FIG.23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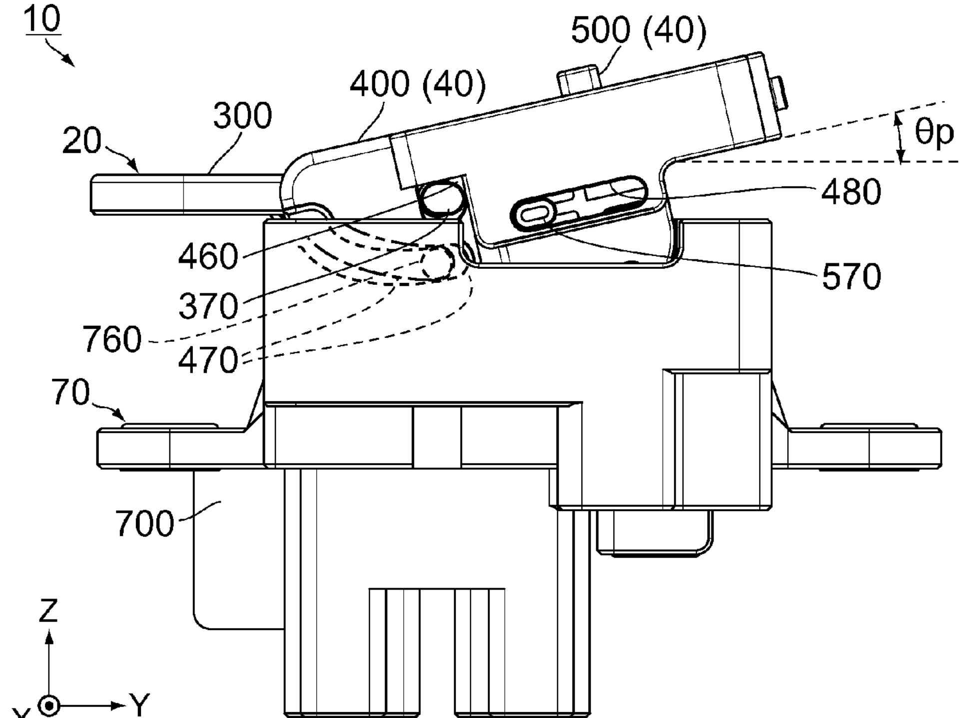
810
810

FIG.24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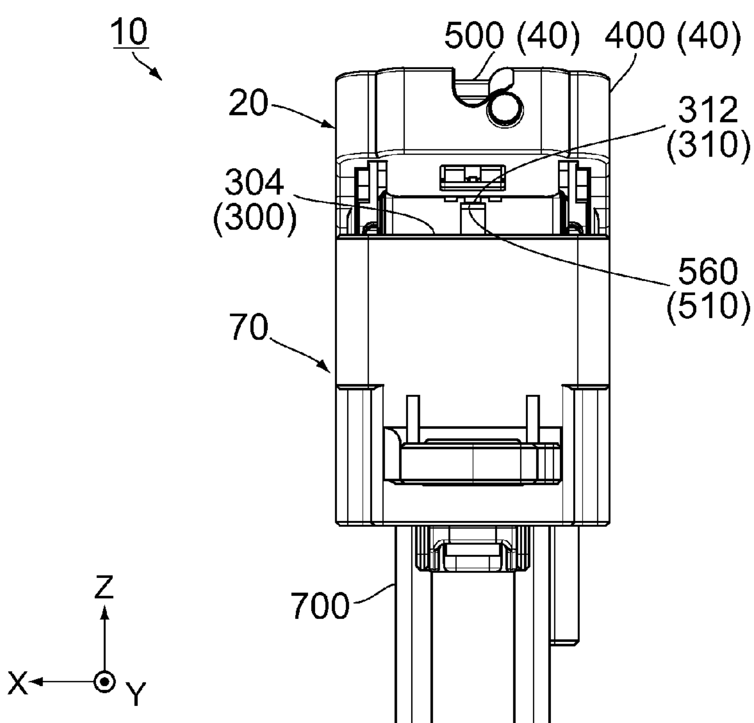
Z
X
Y

FIG.25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(310)
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(300)
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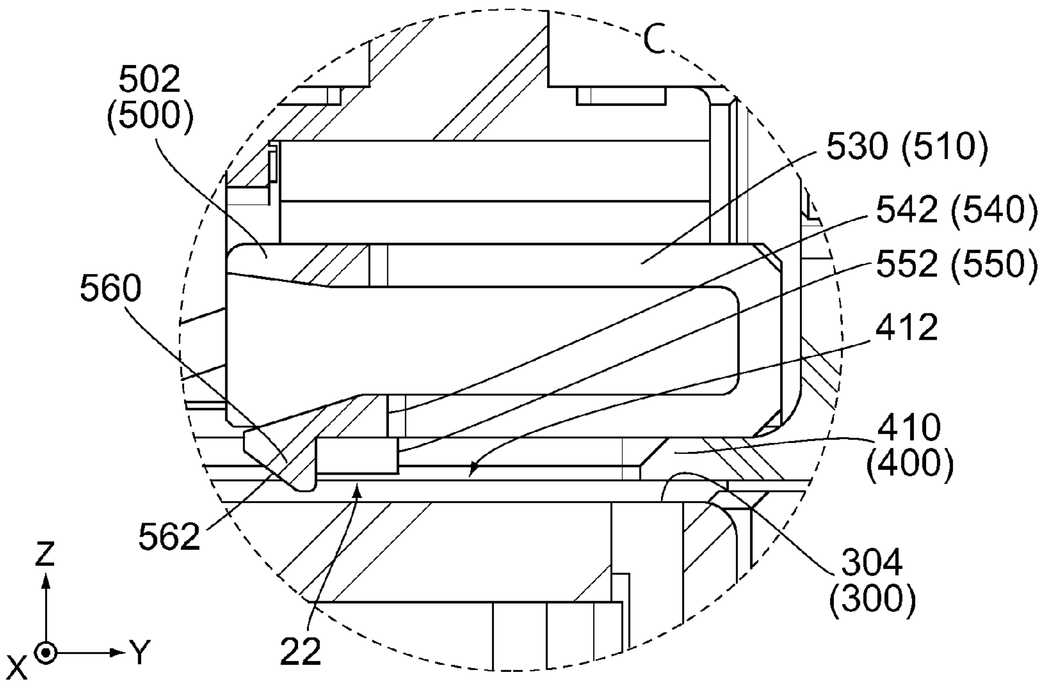
(510)
70
700
Z
X
Y

FIG.26


C
502
(500)
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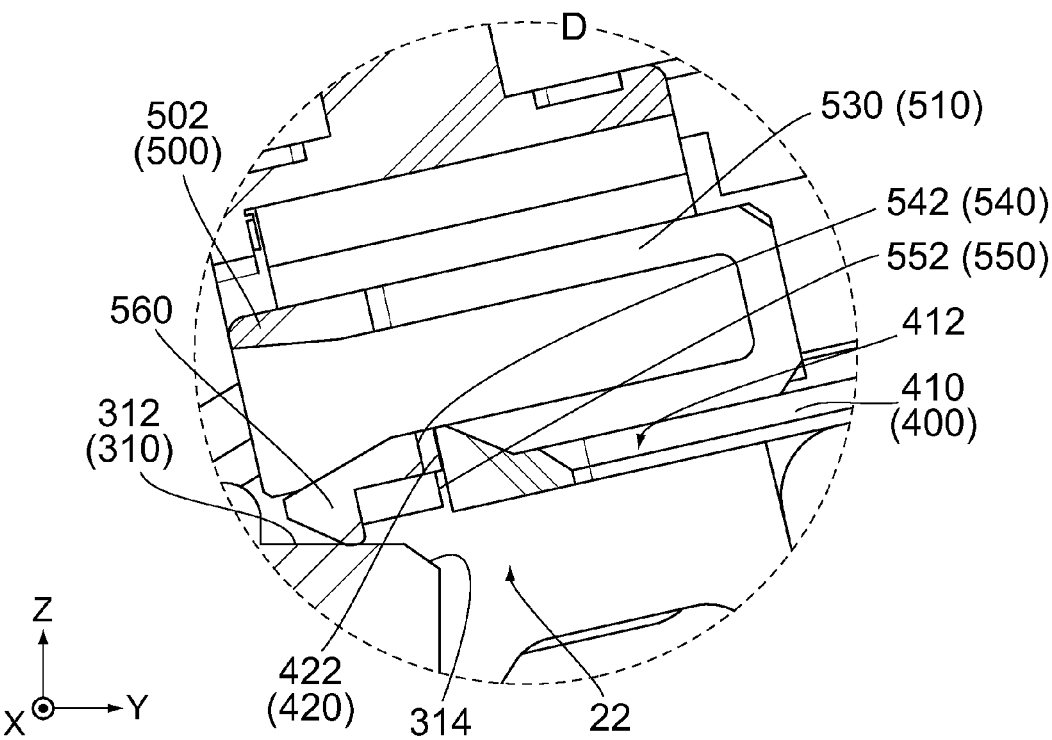
560
412
410
(400)
562
304
(300)
Z
X
Y
22

FIG.27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(310)
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422
(420)
314
22

FIG.28

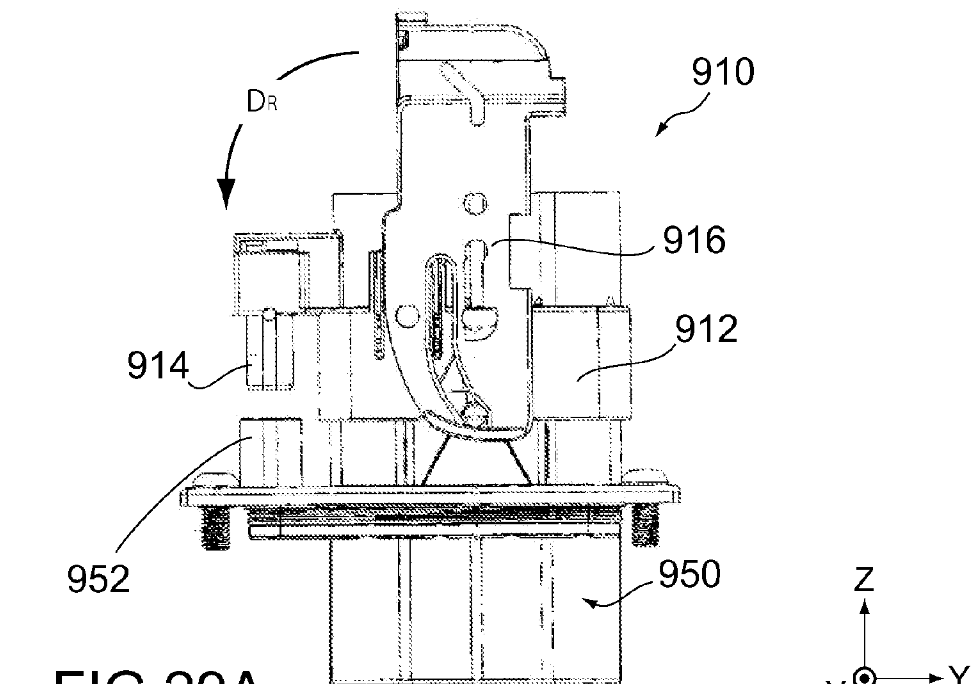

FIG.29A
PRIOR ART

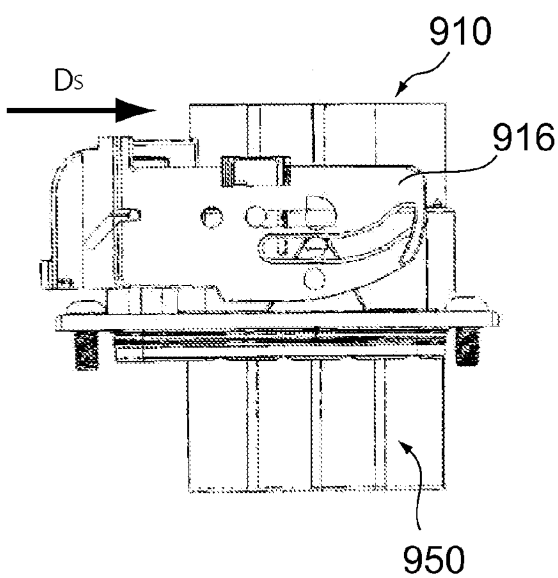

FIG.29B
PRIOR ART

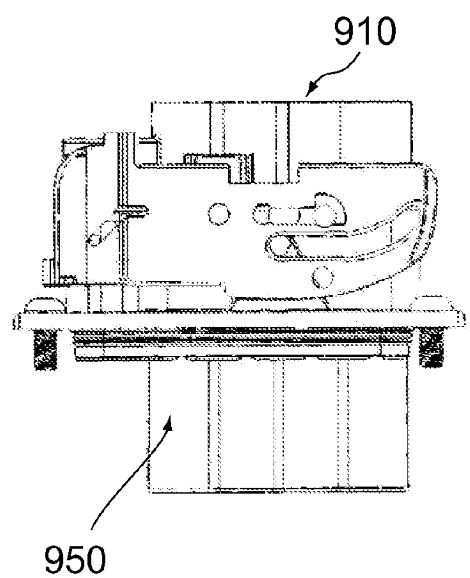

FIG.29C
PRIOR ART

CONNECTOR DEVICE

CROSS REFERENCE TO RELATED APPLICATIONS

Applicants claim priority under 35 U.S.C. §119 of Japanese Patent Application No. JP2014-166462 filed Aug. 19, 2014.

BACKGROUND OF THE INVENTION

This invention relates to a connector device and, in particular, to a connector device which is attached to an electric car or a hybrid car to relay electric power supplied from a power source system.

For example, this type of connector device is disclosed in JP-A 2002-343169 (Patent Document 1), the content of which is incorporated herein by reference.

As shown in FIG. **29**A, the connector device disclosed in Patent Document 1 comprises a connector **910** and a mating connector **950**. The mating connector **950** comprises a mating sub connector **952**. The mating connector **950** holds a mating primary terminal (not shown), and the mating sub connector **952** holds a mating secondary terminal (not shown). The connector **910** comprises a connector housing (housing) **912**, a sub connector **914** and a lever (operation member) **916**. The housing **912** holds a primary terminal (not shown), and the sub connector **914** holds a secondary terminal (not shown).

As shown in FIGS. **29**A and **29**B, a turning operation that turns the operation member **916** in a turning direction DR changes a state of the operation member **916** from an initial state to a first state, or from the state shown in FIG. **29**A to the state shown in FIG. **29**B. When the state of the operation member **916** is changed into the first state, the connector housing **912** is moved downward in an upper-lower direction (Z-direction) so that the primary terminal (not shown) of the connector **910** is connected to the mating primary terminal (not shown) of the mating connector **950**. As shown in FIGS. **29**B and **29**C, subsequent to the turning operation, a sliding operation that makes the operation member **916** slide in a sliding direction Ds changes the state of the operation member **916** from the first state to a second state, or to the state shown in FIG. **29**C. When the state of the operation member **916** is changed into the second state, the sub connector **914** is moved downward so that the secondary terminal (not shown) of the connector **910** is connected to the mating secondary terminal (not shown) of the mating connector **950**. As a result, an electric current begins to flow.

FIGS. **29**B and **29**C show that the first state and the second state of the operation member **916** are visually confused with each other. Accordingly, in such a case where the operation is suspended at the time when the operation member **916** is turned, an operator might misunderstand as if the lever **916** is already made slide so that the operation is completed. Unless such misunderstanding is made clear, the electric current will never flow.

SUMMARY OF THE INVENTION

It is therefore an object of the present invention to provide a connector device which comprises a connector and a mating connector connectable with each other via two or more operations of the operation member and which easily allows visual recognition of whether the operation of the operation member is completed or not.

One aspect of the present invention provides a connector device comprising a connector and a mating connector connectable with each other. The mating connector comprises a mating housing, a mating primary terminal and a mating secondary terminal. The mating primary terminal and the mating secondary terminal are held by the mating housing. The connector comprises a housing, a primary terminal, a secondary terminal, an operation member and a push-back mechanism. The primary terminal is held by the housing. The operation member is attached to the housing. A movement of a part or whole of the operation member relative to the housing causes a state of the operation member to be changed from an initial state to a first state, and another movement of a part or whole of the operation member relative to the housing causes the state of the operation member to be changed from the first state to a second state. When the operation member is in the initial state, the primary terminal is unconnected to the mating primary terminal, and the secondary terminal is unconnected to the mating secondary terminal. When the state of the operation member is changed from the initial state to the first state, the primary terminal is moved relative to the mating primary terminal to be connected to the mating primary terminal. When the state of the operation member is changed from the first state to the second state, the secondary terminal is moved relative to the mating secondary terminal to be connected to the mating secondary terminal. When the state of the operation member is changed to the first state, the push-back mechanism applies a push-back force to the operation member, wherein the push-back force pushes back the operation member to change the state of the operation member back toward the initial state.

According to the present invention, the operation of the operation member is completed when the state of the operation member is changed from the initial state to the second state via the first state. When the state of the operation member is changed to the first state, the push-back mechanism applies the push-back force to the operation member, wherein the push-back force pushes back the operation member to change the state of the operation member back toward the initial state. The operation member is therefore actually pushed back and changes its state toward the initial state if the operation of the operation member is suspended. The connector device thus easily allows visual recognition of whether the operation of the operation member is completed or not.

An appreciation of the objectives of the present invention and a more complete understanding of its structure may be had by studying the following description of the preferred embodiment and by referring to the accompanying drawings.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. **1** is a perspective view showing a connector device according to an embodiment of the present invention, wherein an operation member of a connector of the connector device is in an initial state.

FIG. **2** is a top view showing the connector device of FIG. **1**.

FIG. **3** is a partially cut-away view showing the connector device of FIG. **2**, taken along line III-III, wherein a primary terminal and a secondary terminal of the connector and a mating primary terminal and a mating secondary terminal of a mating connector are illustrated not in cross-sectional views but in side views.

FIG. **4** is a perspective view showing the connector device of FIG. **1**, wherein the operation member of the connector is in a first state while taking a controlled posture, and cables extending outward from the mating connector are not illustrated.

FIG. **5** is a partially cut-away view showing the connector device of FIG. **4**, wherein illustrated cross-sections correspond to the cross-sections of FIG. **3**.

FIG. **6** is a perspective view showing the connector device of FIG. **1**, wherein the operation member of the connector is in a second state, and the cables extending outward from the mating connector are not illustrated.

FIG. **7** is a partially cut-away view showing the connector device of FIG. **6**, wherein illustrated cross-sections correspond to the cross-sections of FIG. **3**.

FIG. **8** is a perspective view showing a housing of the connector of the connector device of FIG. **6**.

FIG. **9** is a perspective view showing a lever of the connector of the connector device of FIG. **6**.

FIG. **10** is another perspective view showing the lever of FIG. **9**.

FIG. **11** is a side view showing the lever of FIG. **9**, wherein dashed line illustrates a modification of the lever, especially, a part of an outline of an extended part of a first cam groove and a part of an outline of an extended part of a support hole.

FIG. **12** is a top view showing the lever of FIG. **9**.

FIG. **13** is a perspective view showing a slider of the connector of the connector device of FIG. **6**.

FIG. **14** is another perspective view showing the slider of FIG. **13**.

FIG. **15** is a side view showing the slider of FIG. **13**.

FIG. **16** is a rear view showing the slider of FIG. **13**.

FIG. **17** is a bottom view showing the slider of FIG. **13**.

FIG. **18** is a cross-sectional view showing the slider of FIG. **17**, taken along line XVIII-XVIII, wherein dashed line illustrates an outline of a spring piece of the slider which is resiliently deformed.

FIG. **19** is a cross-sectional view showing the slider of FIG. **17**, taken along line XIX-XIX, wherein dashed line illustrates an outline of the spring piece which is resiliently deformed.

FIG. **20** is an enlarged, cross-sectional view showing the vicinity of the spring piece (the part encircled by dash line A) of the connector device of FIG. **3**.

FIG. **21** is an enlarged, cross-sectional view showing the vicinity of the spring piece (the part encircled by dash line B) of the connector device of FIG. **5**.

FIG. **22** is a perspective view showing the slider of the connector device of FIG. **21**.

FIG. **23** is a perspective view showing the connector device of FIG. **1**, wherein the operation member of the connector is in the first state while taking a released posture, and the cables extending outward from the mating connector are not illustrated.

FIG. **24** is a partially cut-away view showing the connector device of FIG. **23**, wherein illustrated cross-sections correspond to the cross-sections of FIG. **3**.

FIG. **25** is a side view showing the connector device of FIG. **23**, wherein dashed line illustrates an outline of a part of the first cam groove of the lever hidden behind the mating connector and an outline of a first cam projection of the mating connector, and chain dotted line illustrates an outline of the first cam groove under a state where the operation member takes the controlled posture.

FIG. **26** is a front view showing the connector device of FIG. **23**.

FIG. **27** is an enlarged, cross-sectional view showing the vicinity of the spring piece (the part encircled by dash line C) of the connector device of FIG. **7**.

FIG. **28** is an enlarged, cross-sectional view showing the vicinity of the spring piece (the part encircled by dash line D) of the connector device of FIG. **24**.

FIGS. **29**A, **29**B and **29**C are side views each showing a connector device of Patent Document 1.

While the invention is susceptible to various modifications and alternative forms, specific embodiments thereof are shown by way of example in the drawings and will herein be described in detail. It should be understood, however, that the drawings and detailed description thereto are not intended to limit the invention to the particular form disclosed, but on the contrary, the intention is to cover all modifications, equivalents and alternatives falling within the spirit and scope of the present invention as defined by the appended claims.

DESCRIPTION OF PREFERRED EMBODIMENTS

Referring to FIG. **1**, a connector device **10** according to an embodiment of the present invention is to be installed to an object (not shown) such as an electric car to transmit electric power supplied from an electric source system (not shown), for example, to a motor (not shown). However, the present invention is also applicable to a connector device unlike the connector device **10** which transmits the electric power.

As can be seen from FIGS. **1** to **7**, the connector device **10** according to the present embodiment comprises a connector **20** and a mating connector **70** connectable with each other.

Referring to FIG. **3**, the mating connector **70** comprises a mating housing **700** made of insulator, two mating primary terminals **780** each made of conductor and two mating secondary terminals **790** each made of conductor. The mating primary terminals **780** and the mating secondary terminals **790** are held by the mating housing **700**. The mating primary terminals **780** are connected to an electric power circuit (not shown) via cables **810**. The mating secondary terminal **790** are connected to a switch (not shown) of the electric power circuit via cables **820**.

As can be seen from FIGS. **1** to **3**, the mating housing **700** has a box-like shape which is long in a front-rear direction (Y-direction) and is short in a width direction (X-direction). The mating housing **700** has an accommodation portion (accommodation space) **710** which is formed therewithin and opens upward in an upper-lower direction (Z-direction), or opens in the positive Z-direction. Referring to FIG. **1**, the mating housing **700** has two first cam projections **760**. The first cam projections **760** are provided to opposite sidewalls of the accommodation portion **710** in the X-direction, respectively, and project inward in the X-direction.

Referring to FIG. **3**, the connector **20** comprises a housing **300** made of insulator, a primary terminal **390** made of conductor, an operation member **40** made of insulator, a sub connector **600** made of insulator and a secondary terminal **690** made of conductor. The sub connector **600** is attached to the housing **300**. The primary terminal **390** is held by the housing **300**, and the secondary terminal **690** is held by the sub connector **600**.

As can be seen from FIGS. **1**, **3** and **4**, the operation member **40** is attached to the housing **300**. In detail, the operation member **40** according to the present embodiment includes a lever **400** and a slider **500**. The lever **400** is attached to the housing **300**, and the slider **500** is attached to the lever **400**.

As can be seen from FIGS. **1** to **7**, the operation member **40** is movable relative to the housing **300**. In detail, as can be seen from FIGS. **1** to **5**, the lever **400** is movable between a first position (the position shown in FIGS. **1** to **3**) and a second position (the position shown in FIGS. **4** and **5**) together with the slider **500**, wherein each of the first position and the second position is a position relative to the housing **300**. In addition, as can be seen from FIGS. **4** to **7**, the slider **500** is solely movable between a first relative position (the position shown in FIGS. **4** and **5**) and a second relative position (the position shown in FIGS. **6** and **7**), wherein each of the first relative position and the second relative position is a position relative to the lever **400**.

As can be seen from FIGS. **3**, **5** and **7**, the movement of the operation member **40** relative to the housing **300** causes the housing **300** to be moved relative to the mating housing **700**. The subsequent movement of the operation member **40** relative to the housing **300** causes the sub connector **600** to be moved relative to the mating housing **700**.

Hereafter, explanation will be made about detailed structure of the connector **20** in relation to the aforementioned relative movements.

Referring to FIG. **8**, the housing **300** has a box-like shape which is long in the Y-direction and is short in the X-direction. As can be seen from FIG. **3**, the housing **300** has an inner space which opens downward, or opens in the negative Z-direction. Referring to FIG. **8**, the housing **300** has two sidewalls **308**. The sidewalls **308** are located at opposite sides of the housing **300** in the X-direction, respectively. Each of the sidewalls **308** is formed with a support axis **370** and a guide channel **380**. The support axis **370** projects outward in the X-direction. The guide channel **380**, which is a slit across the sidewall **308** in the X-direction, extends upward from a lower end, or the negative Z-side end, of the sidewall **308**.

As shown in FIGS. **9** to **12**, the lever **400** has a front wall **402** and two sidewalls **408**. The sidewalls **408** are located at opposite sides of the lever **400** in the X-direction, respectively. The front wall **402** couples the two sidewalls **408** to each other in the X-direction. Each of the sidewalls **408** is formed with a support hole **460**, a first cam groove **470** and a slide channel **480**. The support hole **460** pierces the sidewall **408** in the X-direction. The first cam groove **470** is a recess which is recessed inward in the X-direction, and the slide channel **480** is a slit across the sidewall **408** in the X-direction. As can be seen from FIGS. **1** and **9**, when the lever **400** is located at the first position, or the position shown in FIG. **1**, the first cam groove **470** opens downward and extends obliquely upward to the vicinity of the support hole **460**. As shown in FIG. **4**, when the lever **400** is located at the second position, the slide channel **480** extends in the Y-direction.

As shown in FIGS. **13** to **15**, the slider **500** has a coupling portion **502** and two sidewalls **508**. The sidewalls **508** are located at opposite sides of the slider **500** in the X-direction, respectively. The coupling portion **502** couples the two sidewalls **508** to each other in the X-direction. Each of the sidewalls **508** is formed with a slide projection **570** and a second cam groove **580**. The slide projection **570** projects outward in the X-direction. The second cam groove **580** is a slit across the sidewall **508** in the X-direction.

As can be seen from FIGS. **1** and **4**, the slider **500** is attached between the two sidewalls **408** of the lever **400**. In detail, the two slide projections **570** of the slider **500** are inserted into the two slide channels **480** of the lever **400**, respectively. The slider **500** is therefore sandwiched between the two sidewalls **408**, and each of the slide projections **570** is located at one of ends of the corresponding slide channel **480**, or at the negative Y-side end in FIG. **4**. As described later, a second operation can move the slider **500** from this first relative position toward the second relative position along the slide channel **480**.

As can be seen from FIGS. **1** and **4**, the lever **400** together with the slider **500** attached thereto is attached to the housing **300** so as to sandwich the housing **300** in the X-direction. In detail, the two support axes **370** of the housing **300** are inserted into the two support holes **460** (see FIG. **9**) of the lever **400**, respectively. The housing **300** is therefore sandwiched between the two sidewalls **408** of the lever **400**. The lever **400** is turnable about the support axes **370**. More specifically, a first operation described later can rotationally move the lever **400** from this first position toward the second position.

Referring to FIG. **1**, the sub connector **600** has two second cam projections **670**. The second cam projections **670** are located at opposite sides of the sub connector **600** in the X-direction, respectively. The second cam projections **670** project outward in the X-direction. The sub connector **600** is accommodated and attached in the inner space of the housing **300**. In detail, the two second cam projections **670** of the sub connector **600** are inserted into the guide channels **380** of the housing **300**, respectively. The thus-attached sub connector **600** is movable along the guide channels **380**. The second cam projections **670** pass through the guide channels **380**, respectively, to project outward from the housing **300**.

As can be seen from FIGS. **1** and **2**, the connector **20** has a lower part, or the negative Z-side part, which has a size in the XY-plane slightly smaller than another size of the accommodation portion **710** of the mating housing **700** in the XY-plane. The connector **20** can be therefore inserted into the accommodation portion **710** along a connection direction (negative Z-direction).

Hereafter, more specific explanation will be made on how the connector **20** and the mating connector **70** are connected with each other.

First, as can be seen from FIG. **1**, the connector **20** is placed above the mating connector **70** under a state where the operation member **40** including the lever **400** and the slider **500** extends upward from the housing **300**. Then, the connector **20** is inserted into the accommodation portion **710** along the negative Z-direction while positioned in the XY-plane properly. This insertion causes the first cam projections **760** of the mating housing **700** to be received in lower ends of the first cam grooves **470** of the lever **400**, respectively. The state which the operation member **40** takes at that time is referred to as “initial state”. The operation member **40** in the initial state stands upright with respect to the housing **300**. When the operation member **40** is in the initial state, the lever **400** is located at the first position and the slider **500** is located at the first relative position.

As can be seen from FIG. **3**, when the operation member **40** is in the initial state, the primary terminal **390** is unconnected to the mating primary terminals **780**. The mating primary terminals **780** are therefore disconnected from each other so that the electric power circuit (not shown) is broken. In the meantime, the mating secondary terminals **790** are also disconnected from each other because the secondary terminal **690** is similarly unconnected to the mating secondary terminals **790**. In other words, the initial state is a state where the operation member **40** completely electrically disconnects the connector **20** and the mating connector **70** from each other.

As can be seen from FIGS. **1** and **3** to **5**, the first operation of the operation member **40** under the initial state turns the lever **400** about the support axes **370**, wherein the first operation is an operation which turns the front wall **402** of the lever **400** forward and downward, or along the positive Y-direction and the negative Z-direction. During the first operation, the first cam projections **760** of the mating housing **700** are located at predetermined positions with no movement. Accordingly, the lever **400** is moved downward while bringing lower edges, or the negative Z-side edges, of the first cam grooves **470** into contact with the first cam projections **760**, respectively. The support axes **370** are pressed downward because of the downward movement of the lever **400** so that the housing **300** is moved downward together with the lever **400**. When the first operation is completed, the first cam projections **760** are located at ends of the first cam grooves **470**, respectively. The state which the operation member **40** takes at the time when the first operation is completed is referred to as "first state". When the state of the operation member **40** is changed from the initial state to the first state, the lever **400** is moved to the second position but the slider **500** remains at the first relative position.

As shown in FIG. **4**, when the first operation is just completed, the operation member **40** extends long along the Y-direction. At that time, as can be seen from FIGS. **1** and **4**, the second cam projections **670** of the sub connector **600** are received in upper ends, or the positive Z-side ends, of the second cam grooves **580** of the slider **500**, respectively.

As can be seen from FIGS. **3** and **5**, the first operation moves the primary terminal **390** downward. When the first operation is completed, the primary terminal **390** is connected to the mating primary terminals **780**. In other words, when the state of the operation member **40** is changed from the initial state to the first state, the primary terminal **390** is moved relative to the mating primary terminals **780** to be connected to the mating primary terminals **780**. The mating primary terminals **780** are therefore connected with each other to complete the electric power circuit (not shown). However, the mating secondary terminals **790** are not connected with each other because the secondary terminal **690** is not connected to the mating secondary terminals **790**. No electric current therefore flows. In other words, the first state is a state where the operation member **40** partially electrically connects the connector **20** and the mating connector **70** with each other.

As can be seen from the above explanation, the state of the operation member **40** according to the present embodiment is changeable from the initial state (the state shown in FIGS. **1** to **3**) to the first state (the state shown in FIGS. **4** and **5**). In detail, a movement of whole of the operation member **40**, or a movement of the lever **400** together with the slider **500**, relative to the housing **300** causes the state of the operation member **40** to be changed from the initial state to the first state.

As can be seen from FIGS. **4** and **6**, the second operation of the operation member **40** under the first state moves each of the slide projections **570** from a rear end to a front end, or from the negative Y-side end to the positive Y-side end, of the corresponding slide channel **480**, wherein the second operation is an operation which makes the slider **500** slide forward. Referring to FIG. **1** as well as FIGS. **4** and **6**, during the second operation, the second cam projections **670** of the sub connector **600** are moved along the second cam grooves

580 of the slider **500**, respectively. Accordingly, as can be seen from FIGS. **5** and **7**, the sub connector **600** is moved downward. Referring to FIGS. **4** and **6**, when the slide projections **570** arrive at the front ends of the slide channels **480**, the second operation is completed. The state which the operation member **40** takes at the time when the second operation is completed is referred to as "second state". When the state of the operation member **40** is changed from the first state to the second state, the slider **500** is moved forward in the Y-direction from the first relative position to the second relative position. In the meantime, the lever **400** remains at the second position. In other words, when the state of the operation member **40** is changed to the second state, the lever **400** remains at the second position but the slider **500** is moved to the second relative position.

As can be seen from FIGS. **5** and **7**, the second operation does not move the primary terminal **390**. The electric power circuit (not shown) is therefore maintained. In the meantime, the second operation moves the secondary terminal **690** downward. When the second operation is completed, the secondary terminal **690** is connected to the mating secondary terminals **790**. In other words, when the state of the operation member **40** is changed from the first state to the second state, the secondary terminal **690** is moved relative to the mating secondary terminals **790** to be connected to the mating secondary terminals **790**. The mating secondary terminals **790** are therefore connected with each other to close the switch (not shown) of the electric power circuit (not shown). As a result, the electric current begins to flow. In other words, the second state is a state where the operation member **40** completely electrically connects the connector **20** and the mating connector **70** with each other.

As can be seen from the above explanation, the state of the operation member **40** according to the present embodiment is changeable from the first state (the state shown in FIGS. **4** and **5**) to the second state (the state shown in FIGS. **6** and **7**). In detail, a movement of a part of the operation member **40**, or a movement of the slider **500**, relative to the housing **300** causes the state of the operation member **40** to be changed from the first state to the second state.

As can be seen from FIGS. **1** to **7**, the connector **20** can be removed from the mating connector **70** when the aforementioned operations are performed in reverse sequence. In detail, first, the slider **500** is moved from the second relative position to the first relative position so that the state of the operation member **40** is changed from the second state to the first state. This operation disconnects the secondary terminal **690** from the mating secondary terminals **790** to stop the electric current. Then, the lever **400** is turned up to be moved from the second position to the first position so that the state of the operation member **40** is changed from the first state to the initial state. This operation disconnects the primary terminal **390** from the mating primary terminals **780** to break the electric power circuit (not shown). When the operation member **40** returns to the initial state, the connector **20** can be removed upward from the mating connector **70**.

The connector device **10** formed as described above can be modified variously.

Referring to FIGS. **3**, **5** and **7**, the lever **400** and the slider **500** may be formed integrally with each other. In other words, the operation member **40** may be formed only of the lever **400** which allows both the first operation and the second operation. Referring to FIG. **11** as well as FIGS. **3**, **5** and **7**, when the operation member **40** is thus formed, the structure of each of the sidewalls **408** of the lever **400** may be slightly modified. For example, the support hole **460** and the first cam groove **470** may be made longer so as to extend forward. This structure allows the state of the operation member **40** to be changed from the first state to the second state with no movement of the housing **300**, in particular, with no movement of the primary terminal **390**. When the operation member **40** is thus-modified, a movement of whole of the operation member **40** relative to the housing **300** causes the state of the operation member **40** to be changed from the initial state to the first state, and another movement of whole of the operation member **40** relative to the housing **300** causes the state of the operation member **40** to be changed from the first state to the second state.

When the operation member **40** is in the initial state, the slider **500** may be coupled to the sub connector **600** without being attached to the lever **400**. For example, each of the slide projections **570** may be formed to be inserted into the corresponding slide channel **480** as a result of the change of the state of the operation member **40** into the first state. In this case, when the state of the operation member **40** is changed from the initial state to the first state, only a part of the operation member **40**, or only the lever **400**, is moved relative to the housing **300**. In addition to the aforementioned modifications, the operation member **40** may includes any one or more operational members instead of and different from the lever **400** and the slider **500**. Moreover, the operation member **40** may be formed of only one member or formed of three or more members.

As can be seen from the above explanation, according to the present invention, a movement of a part or whole of the operation member **40** relative to the housing **300** causes the state of the operation member **40** to be changed from the initial state to the first state, and another movement of a part or whole of the operation member **40** relative to the housing **300** causes the state of the operation member **40** to be changed from the first state to the second state. In other words, the connector **20** can be connected with the mating connector **70** via the two operations. However, the connector **20** may be connected with the mating connector **70** via three or more operations. Moreover, operations of the operation member **40** may be different from the aforementioned first and second operations.

Hereafter, more details will be explained about the housing **300** and the operation member **40** according to the present embodiment.

As shown in FIG. **8**, the housing **300** has an upper surface **302** and a step surface **304**. Each of the upper surface **302** and the step surface **304** is a horizontal plane in parallel to the XY-plane. The housing **300** is provided with a step formed between the upper surface **302** and the step surface **304**. In detail, the step surface **304** is located below the upper surface **302**. Referring to FIGS. **7** and **8**, the connector **20** is provided with a receiving space **22** because of the thus-formed step. In the present embodiment, the receiving space **22** opens in the XY-plane and opens upward. However, the receiving space **22** may be enclosed by a wall in the XY-plane, provided that the receiving space **22** opens upward.

The step surface **304** of the housing **300** is provided with a projecting portion **310**. The projecting portion **310** projects upward in the Z-direction from the step surface **304**. The projecting portion **310** is formed with an upper surface **312** and a slope **314**. The upper surface **312** is a horizontal plane located at an upper end of the projecting portion **310**. The slope **314** is formed at a front side, or the positive Y-side, of the projecting portion **310**. In other words, the projecting portion **310** has the front side formed with the slope **314**. The slope **314** extends forward and downward from the upper surface **312**. In other words, the slope **314** intersects with both the Y-direction and the Z-direction.

As shown in FIGS. **9**, **10** and **12**, the lever **400** has a support piece **410**. The support piece **410** has a rectangular flat plate-like shape. As shown in FIG. **5**, when the lever **400** is located at the second position, the support piece **410** extends rearward, or in the negative Y-direction, from the front wall **402**. Hereafter, explanation will be made about various parts of the support piece **410** while using directions and positional relations under a state where the lever **400** is located at the second position.

As shown in FIGS. **9**, **10** and **12**, the support piece **410** is formed with a receiving portion **412**. The receiving portion **412** is a rectangular hole which pierces the support piece **410** in the Z-direction. The receiving portion **412** has a rear end formed with a slope **414**. The slope **414** intersects with both the Y-direction and the Z-direction.

As shown in FIGS. **9** and **12**, the lever **400** has a sloping portion **420**, an engaged portion **422** and a slope **424**. The sloping portion **420** is formed at a rear end of the support piece **410** and located rearward of the slope **414**. The engaged portion **422** is formed at a rear side, or the negative Y-side, of the sloping portion **420**, and the slope **424** is formed at a front side of the sloping portion **420**. In other words, the sloping portion **420** is formed with the engaged portion **422** and the slope **424**. The engaged portion **422** is a vertical plane perpendicular to the Y-direction, and the slope **424** intersects with both the Y-direction and the Z-direction.

As shown in FIGS. **10** and **12**, the lever **400** has an engaged portion **430**. The engaged portion **430** according to the present embodiment is a rear edge of the support piece **410** and is a vertical plane perpendicular to the Y-direction.

As shown in FIGS. **13** to **17**, the slider **500** has a push-back mechanism (spring piece) **510**. In other words, the connector **20** comprises the push-back mechanism **510**. The push-back mechanism **510** according to the present embodiment is the spring piece **510** and is made of resin, wherein the spring piece **510** is integrally formed with the slider **500**. The spring piece **510** may be formed separately from the slider **500** and subsequently fixed to the slider **500**. The thus-formed spring piece **510** may be made of metal. However, in a view point of reducing the number of components, the spring piece **510** is preferred to be a part of the slider **500**. Hereafter, explanation will be made about various parts of the spring piece **510** while using directions and positional relations under a state where the slider **500** is located at the second relative position.

As shown in FIGS. **14**, **16** and **17**, the spring piece **510** has two spring portions **530** and a movable portion **540**. Referring to FIG. **18**, each of the spring portions **530** has a U-like shape in the YZ-plane. In detail, each of the spring portions **530** extends forward from its fixed end **520** fixed to the coupling portion **502**, subsequently extends downward and subsequently extends rearward. In other words, the spring portion **530** is supported by the coupling portion **502** to be resiliently deformable. As shown in FIGS. **14**, **16** and **17**, the movable portion **540** couples free ends of the spring portions **530** in the X-direction. The movable portion **540** is movable in the Z-direction because of the resilient deformation of the spring portions **530**. The movable portion **540** has a lower surface, or the negative Z-side surface, which is a horizontal plane when the spring portions **530** are not resiliently deformed.

As shown in FIGS. **14** and **17**, the spring piece **510** has an engaging portion **542**. The engaging portion **542** is formed at a frond end of the movable portion **540**. The engaging portion **542** is located between the two spring portions **530** in the X-direction. When the spring portion **530** is not resiliently deformed, the engaging portion **542** is a vertical plane.

As shown in FIGS. **14**, **16** and **17**, the spring piece **510** has two engaging portions **552**. In detail, the lower surface of the movable portion **540** is formed with two projecting portions **550**. The projecting portions **550** are located at opposite sides of the movable portion **540** in the X-direction, respectively. The projecting portions **550** project downward from the movable portion **540**. The engaging portions **552** are formed at the projecting portions **550**, respectively. When the spring portions **530** are not resiliently deformed, each of the engaging portions **552** is a vertical plane.

The lower surface of the movable portion **540** is further formed with a projecting portion **560**. The projecting portion **560** is located at a middle part of the movable portion **540** in the X-direction. The projecting portion **560** projects downward from the movable portion **540**. The projecting portion **560** is formed with a front surface **562** and a slope **566**. The front surface **562** is located at a front side of the projecting portion **560**, and the slope **566** is located at a rear side of the projecting portion **560**. When the spring portions **530** are not resiliently deformed, the front surface **562** is a vertical plane, and the slope **566** intersects with both the Y-direction and the Z-direction.

Referring to FIGS. **3** and **20**, when the operation member **40** is in the initial state, the spring portions **530** of the spring piece **510** are not resiliently deformed. The shape of the spring piece **510** under this state is referred to as "initial shape". In other words, when the operation member **40** is in the initial state, the spring piece **510** has the initial shape.

As shown in FIG. **20**, when the operation member **40** is in the initial state, the engaging portion **542** of the spring piece **510** is located under the engaged portion **422** of the lever **400**. If the slider **500** is forced to be moved upward toward the second relative position, the engaging portion **542** is brought into abutment with the engaged portion **422**. This abutment prevents the slider **500** from being moved to the second relative position. Moreover, as can be seen from FIGS. **12** and **20**, when the operation member **40** is in the initial state, the engaging portions **552** of the spring pieces **510** are located under the engaged portion **430** of the lever **400**. This positional relation also prevents the slider **500** from being moved to the second relative position. In other words, when the operation member **40** is in the initial state, the engaging portion **542** and the engaging portions **552** engage the engaged portion **422** and the engaged portion **430**, respectively, to prevent the slider **500** from being moved from the first relative position to the second relative position.

As can be seen from FIGS. **5** and **21**, when the state of the operation member **40** is changed to the first state, the projecting portion **560** of the spring piece **510** is brought into abutment with the upper surface **312** of the projecting portion **310** of the housing **300**. The projecting portion **560** is therefore pressed upward to be moved. Accordingly, as shown in FIGS. **21** and **22**, when the state of the operation member **40** is changed to the first state, the spring piece **510** is resiliently deformed from the initial shape. The resiliently deformed spring piece **510** presses the projecting portion **310** downward.

As can be seen from FIGS. **5** and **21**, when the state of the operation member **40** is changed from the initial state to the first state, the spring piece **510** applies a push-back force to the operation member **40**, wherein the push-back force pushes back the operation member **40** to change the state of the operation member **40** back toward the initial state (the state shown in FIG. **3**). However, during the operation of the operation member **40** by an operator, the operation applies an operation force to the operation member **40**, wherein the operation force (maintaining force) can resist this push-back force. This maintaining force causes the operation member **40** to take a controlled posture shown in FIG. **5**, or a posture extending along the Y-direction, while resiliently deforming the spring piece **510**. In other words, under a condition where the operation member **40** is in the first state and the operation member **40** receives the maintaining force which resists the push-back force, the operation member **40** takes the controlled posture. According to the present embodiment, when the operation member **40** takes the controlled posture, the lever **400** is located at the second position.

As can be seen from FIGS. **24** and **28**, for example, if the operator temporarily suspends the operation of the operation member **40** and releases the operation member **40** from his/her hand, the operation member **40** receives no maintaining force. Moreover, referring to FIG. **25**, when the operation member **40** is in the first state, each of the first cam projections **760** of the mating housing **700** is located in the vicinity of the corresponding support axis **370** of the housing **300** to allow the corresponding first cam groove **470** to be rotationally moved to some extent. Accordingly, the push-back force actually pushes back the operation member **40** and the state of the operation member **40** is changed toward the initial state (see FIG. **3**).

Referring to FIGS. **23** to **26**, the operation member **40** in the first state extends obliquely upward from the housing **300** when receiving no maintaining force. The posture of the operation member **40** under this state is referred to as "released posture". In other words, under a condition where the operation member **40** is in the first state and the operation member **40** receives no maintaining force, the operation member **40** takes the released posture which is different from the controlled posture. Referring to FIG. **25**, the operation member **40** intersects with the Y-direction at a predetermined intersection angle (θp) when taking the released posture. This predetermined intersection angle (θp) can be variously designed depending on modification of the level of the spring force of the spring piece **510** (see FIG. **22**) as well as modification of the shape and the size of the first cam groove **470** of the lever **400**.

Referring to FIGS. **4** and **23**, the released posture, or the posture of the operation member **40** under a state where the operation is temporarily suspended, is clearly different from the controlled posture, or the posture of the operation member **40** during the operation. Accordingly, the operation member **40** can be easily visually checked whether the operation thereof is completed or not.

Referring to FIGS. **5** and **24**, the push-back mechanism **510** according to the present embodiment is provided to the operation member **40**. More specifically, the push-back mechanism **510** according to the present embodiment is the spring piece **510** provided to the slider **500**. According to the present embodiment, when the state of the operation member **40** is changed to the first state, the push-back mechanism **510** presses the housing **300** to cause the aforementioned push-back force.

Referring to FIGS. **5** and **24**, according to the present embodiment, the push-back mechanism **510** applies the push-back force indirectly to the lever **400** via the slider **500**. However, for example, when the operation member **40** is formed only of the lever **400**, the push-back mechanism **510** applies the push-back force directly to the lever **400**. Thus, according to the present invention, the push-back mechanism **510** applies the push-back force directly or indirectly to the lever **400**.

As can be seen from FIG. **28**, if the operation of the operation member **40** is temporarily suspended under the first state, the engaging portion **542** and the engaging portions **552** of the slider **500** engage the engaged portion **422** and the engaged portion **430** (see FIG. **12**) of the lever **400**, respectively, to prevent the slider **500** from being moved from the first relative position to the second relative position. As can be seen from FIG. **21**, when the operation member **40** during the operation is in the first state, the engaging portion **542** and the engaging portions **552** are moved upward to come off the engaged portion **422** and the engaged portion **430**, respectively. The slider **500** can be therefore moved toward the second relative position. In other words, when the state of the operation member **40** is just changed to the first state, the engaging portion **542** and the engaging portions **552** allow the slider **500** to be moved from the first relative position to the second relative position. Similarly, when the suspended operation is resumed so that the operation member **40** in the first state takes back its controlled posture, the engaging portion **542** and the engaging portions **552** allow the slider **500** to be moved from the first relative position to the second relative position.

As shown in FIG. **21**, when the state of the operation member **40** is changed to the first state, the sloping portion **420** of the lever **400** is located forward of and below the slope **314** of the projecting portion **310** of the housing **300**. In detail, when the operation member **40** during the operation is in the first state, the slope **314** of the projecting portion **310** and the slope **424** of the sloping portion **420** roughly continuously extend with a narrow horizontal plane interposed therebetween.

Accordingly, when the slider **500** is moved toward the second relative position, the projecting portion **560** of the slider **500** is gradually moved downward. This gradual movement prevents generation of unnecessary click feeling which might be generated because of rapid and large resilient-deformation of the spring portions **530**. In particular, each of the slope **314** and the slope **424** according to the present embodiment intersects with the Y-direction at about 45°. This intersection angle more surely prevents the click feeling from being generated.

As can be seen from FIGS. **21** and **27**, when the slider **500** of the operation member **40** in the first state is moved to the second relative position, the projecting portion **560** passes the sloping portion **420** and arrives at the receiving portion **412**. At that time, the projecting portion **560** is received into the receiving portion **412** and the receiving space **22** of the housing **300**. In detail, as shown in FIG. **27**, when the slider **500** is located at the second relative position, a lower end of the projecting portion **560** projects downward while passing through the receiving portion **412**. According to the present embodiment, since the receiving space **22** is provided under the receiving portion **412**, the spring piece **510** is partially received in the receiving space **22** and returns to the initial shape. Accordingly, the spring property of each of the spring portions **530** of the spring piece **510** can be kept even if the slider **500** is maintained at the second relative position for a long time. It is sufficient that the spring piece **510** is received, at least in part, in the receiving space **22**, provided that the spring property can be kept.

As can be seen from FIG. **21**, the slope **424** and the slope **414** also roughly continuously extend with a narrow horizontal plane interposed therebetween. Accordingly, also when the projecting portion **560** is received into the receiving space **22**, the projecting portion **560** is not largely moved downward. This structure also prevents the unnecessary click feeling from being generated.

Referring to FIGS. **21** and **27**, when the slider **500** is located at the second relative position, the front surface **562** of the projecting portion **560** is inclined similar to the slope **314**, the slope **424** and the slope **414**. Accordingly, the slider **500** can be smoothly moved back to the first relative position from the second relative position.

The connector device **10** according to the present invention can be further variously modified in addition to the already explained modifications. For example, the push-back mechanism **510** may push back not whole of the operation member **40** but a part of the operation member **40**, for example, only the slider **500**. However, in a view point of easy visual check on whether the operation member **40** is in the first state, the operation member **40** is preferred to be totally pushed back.

Moreover, the portion provided to the support piece **410** in the present embodiment, such as the receiving portion **412**, may be provided to a part other than the support piece **410**. Moreover, the shape and the size of the spring piece **510** can be variously modified. Moreover, the push-back mechanism **510** may have any structure, provided that the operation member **40** which changes its state to the first state applies the push-back force to the operation member **40**. For example, the push-back mechanism **510** does not need to be the spring piece **510**.

The push-back mechanism **510** may be provided to a member other than the slider **500**. For example, the push-back mechanism **510** may be a part of the lever **400**. Even in this case, the push-back mechanism **510**, or the spring piece **510**, may be pressed by the housing **300** to be resiliently deformed similar to the aforementioned embodiment when the state of the operation member **40** is changed to the first state. However, the lever **400** is unmoved relative to the housing **300** when the state of the operation member **40** is changed from the first state to the second state. The spring piece **510** provided to the lever **400** is therefore kept to be pressed by the housing **300** and kept to be resiliently deformed even when the operation member **40** is maintained in the second state. This persistent, resilient deformation might degrade the spring property of the spring piece **510**. Under a condition where the spring piece **510** works as the push-back mechanism **510** and the spring property of the spring piece **510** very needs to be kept, the spring piece **510** is preferred to be provided to one of the slider **500** and the housing **300** which change their positional relation relative to each other in association with the change of the state of the operation member **40** from the first state to the second state. The spring piece **510** thus-provided to one of the slider **500** and the housing **300** presses a remaining one of the slider **500** and the housing **300** to cause the push-back force when the state of the operation member **40** is changed to the first state.

The present application is based on a Japanese patent application of JP2014-166462 filed before the Japan Patent Office on Aug. 19, 2014, the contents of which are incorporated herein by reference.

While there has been described what is believed to be the preferred embodiment of the invention, those skilled in the art will recognize that other and further modifications may be made thereto without departing from the spirit of the invention, and it is intended to claim all such embodiments that fall within the true scope of the invention.

What is claimed is:

1. A connector device comprising a connector and a mating connector connectable with each other, wherein:

the mating connector comprises a mating housing, a mating primary terminal and a mating secondary terminal;

the mating primary terminal and the mating secondary terminal are held by the mating housing;

the connector comprises a housing, a primary terminal, a secondary terminal, an operation member and a push-back mechanism;

the primary terminal is held by the housing;

the operation member is attached to the housing;

a movement of a part or whole of the operation member relative to the housing causes a state of the operation member to be changed from an initial state to a first state, and another movement of a part or whole of the operation member relative to the housing causes the state of the operation member to be changed from the first state to a second state;

when the operation member is in the initial state, the primary terminal is unconnected to the mating primary terminal, and the secondary terminal is unconnected to the mating secondary terminal;

when the state of the operation member is changed from the initial state to the first state, the primary terminal is moved relative to the mating primary terminal to be connected to the mating primary terminal;

when the state of the operation member is changed from the first state to the second state, the secondary terminal is moved relative to the mating secondary terminal to be connected to the mating secondary terminal; and

when the state of the operation member is changed to the first state, the push-back mechanism applies a push-back force to the operation member, wherein the push-back force pushes back the operation member to change the state of the operation member back toward the initial state.

2. The connector device as recited in claim 1, wherein:

under a condition where the operation member is in the first state and the operation member receives a maintaining force which resists the push-back force, the operation member takes a controlled posture; and

under another condition where the operation member is in the first state and the operation member receives no maintaining force, the operation member takes a released posture which is different from the controlled posture.

3. The connector device as recited in claim 1, wherein:

the push-back mechanism is provided to the operation member; and

when the state of the operation member is changed to the first state, the push-back mechanism presses the housing to cause the push-back force.

4. The connector device as recited in claim 1, wherein:

the operation member includes a lever and a slider;

the lever is attached to the housing and is movable between a first position and a second position each of which is a position relative to the housing;

the slider is attached to the lever and is movable between a first relative position and a second relative position each of which is a position relative to the lever;

when the operation member is in the initial state, the lever is located at the first position and the slider is located at the first relative position;

when the state of the operation member is changed to the first state, the lever is moved to the second position;

when the state of the operation member is changed to the second state, the slider is moved to the second relative position; and

the push-back mechanism applies the push-back force directly or indirectly to the lever, wherein the push-back force pushes the lever back toward the first position.

5. The connector device as recited in claim 4, wherein:

the push-back mechanism is provided to one of the slider and the housing; and

when the state of the operation member is changed to the first state, the push-back mechanism presses a remaining one of the slider and the housing to cause the push-back force.

6. The connector device as recited in claim 5, wherein the push-back mechanism is provided to the slider.

7. The connector device as recited in claim 6, wherein the push-back mechanism is a spring piece which is integrally formed with the slider.

8. The connector device as recited in claim 7, wherein:

the connector is provided with a receiving space;

when the operation member is in the initial state, the spring piece has an initial shape;

when the state of the operation member is changed to the first state, the spring piece is resiliently deformed from the initial shape; and

when the slider of the operation member in the first state is moved to the second relative position, the spring piece is received, at least in part, in the receiving space to return to the initial shape.

9. The connector device as recited in claim 7, wherein:

when the state of the operation member is changed from the first state to the second state, the slider is moved forward in a front-rear direction from the first relative position to the second relative position;

the housing is provided with a projecting portion which projects upward in an upper-lower direction perpendicular to the front-rear direction;

when the state of the operation member is changed to the first state, the spring piece presses the projecting portion downward;

the projecting portion has a front side formed with a slope;

the lever has a sloping portion formed with a slope; and

when the state of the operation member is changed to the first state, the sloping portion is located forward of and below the slope of the projecting portion.

10. The connector device as recited in claim 7, wherein:

the spring piece has an engaging portion;

the lever has an engaged portion;

when the operation member is in the initial state, the engaging portion engages the engaged portion to prevent the slider from being moved from the first relative position to the second relative position; and

when the state of the operation member is changed to the first state, the engaging portion, which comes off the engaged portion, allows the slider to be moved from the first relative position to the second relative position.

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